DEVELOPMENT OF A MEASURE FOR TECHNOLOGICAL CAPABILITY IN THE INFORMATION AND COMMUNICATIONS TECHNOLOGY INDUSTRY IN NIGERIA

BY

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1.1 Introduction

Information and Communications Technology (ICT) has proved to be a catalyst to fundamental changes in the world's economies and societies. It creates more avenues to earn income, allows access to useful information, enhances the world of work and makes the world a global village (Aderemi, 2006). The ICT industry spans broadcast, electronics and print media, computers, telecommunications and e-commerce activities. As put forward by Oyelaran-Oyeyinka, Adelaja & Abiola (2007), ICT infrastructure is made up of all physical facilities and technologies engaged in delivering and disseminating information and communication services in telecommunications, broadcasting, cable television service, postal service, publishing, printing, computer networks, and a wide range of terminal equipment. The minimum composition of an ICT infrastructure that would bring about social and industrial development include: a functional telecommunications network with voice, data and video transmission to enable an information base that is adequately networked; local production of ICT equipment and materials; a pool of human resources with capacity in telecommunications and other related aspects of the rapidly growing ICT industry; and software development and production of information technology (IT) applications (Oyelaran-oyeyinka, Adelaja & Abiola, 2007).

In Nigeria today, telecommunication activities continues to play a lead role as a central component of the ICT sector. The industry is competitive with a mix of service providers in the private and public sectors in their respective domains. This is consequent upon the deregulation in the industry.

The recognition of the pivotal role of Information Technology (IT) for development became eminent in Nigeria with the formulation and approval of the National Information Technology (IT) Policy in March, 2001. The formulation of the IT policy was a consultative process that brought together major IT stakeholders such as Computer Association of Nigeria (COAN) now known as Computer Society of Nigeria, National Information Technology Professional Associations (NITPAs) now known as Computer Professionals of Nigeria (CPN), Association of Licensed Telecommunication Companies in Nigeria (ALTCON) as well as the Nigerians in the Diaspora. The IT policy has very clear-cut policy goals on the development of the national information backbone. This was to engender seamless interconnectivity in ICT infrastructure development in Nigeria. The policy document stipulated that the government, through the National Information Technology Development Agency (NITDA), shall establish and develop a National Information Infrastructure (NII) backbone as the gateway to the Global Information Infrastructure (GII) interconnecting it with State Information Infrastructure (SII) and the Local Information Infrastructure (LII). The policy also has the objective to promote technological capability in local production of ICT equipment and materials such as computer and telephones. NITDA is expected to work with the private sector in actualising these goals.

Thus, given the importance of ICT, the passing of the policy document in 2001 with one of the objective on the promotion of technological capability; a study on technological capability eight years after the passing of the policy document could be considered as well overdue. Technological capability is one of the crucial determinants of competitiveness as well as economic performance of any industry. From the very early times, the concept technological capability has been referred to as a stock of technological knowledge that an organisation accumulates over time (Raghavendra & Subrahmanya, 2006). It reflects the ability to not only respond speedily through changes in products and processes, but also the ability for innovation which is a flow variable that could provide the cutting edge in competing with other products and even bring about comparative advantage in other sectors aside the original sector of use. The concept of technological capability is linked with theories and models of knowledge, organisational and technological learning, technological change, diffusion, production capacity and innovation. A distinction is drawn in literature (Bell & Pavitt, 1993) between production capacity and technological capability. Both are regarded as stocks of resources however, the former incorporates the resources used to produce industrial goods at given levels of efficiency and given input combinations: equipment (capital-embodied technology), labour skills (operating and managerial know-how and experience), product and input specifications, and organisational systems. Technological capability incorporates the additional and distinct resources needed to generate and manage technical change, including skills, knowledge and experience, and institutional structures and linkages. This distinction is important because of our interest in the dynamics of industrialization, and hence in the resources necessary to generate and manage that dynamism. Altogether, a robust body of studies exist on firm-level technological learning strategies and innovative capability building in developing countries. One of the current challenge for researchers is to refine their research design and strategies to capture and analyse the intricacies of the dynamics of the process of innovative technological capability accumulation not only at the level of firms, but also at the levels of industrial sectors, clusters, regions, and countries in the context of developing nations under increasingly open and inter-connected market place. The purpose of this study is therefore to capture, analyse and develop a system of technological capability measurement and evaluation in ICT firms in Nigeria that could monitor the trajectory of technological capability accumulation and tract parameters that could lead to competitiveness and growth of the sector. The empirical analyses generated by this research and the practical recommendations that emerge from it would serve as key sources of base data for corporate managers, government policy makers, officials of development agencies, and investors to design and implement strategies to speed up innovative technological capability in developing countries (especially Nigeria) ICT sector.

1.2 Statement of the Problem

Technological capability has been recognised as an important input in industrial development. Technological capability incorporates the additional and distinct resources needed to generate and manage technical change, including skills, knowledge and experience, and institutional structures and linkages (Bell and Pavitt, 2003). The level of economic growth and development of a country depend on its ability to accumulate these technological capabilities. For instance the differences among the industrial countries in growth and trade on the one hand and the gap between the developed and the developing countries on the other, can be traced largely to the differences in the extent of investment in activities that could generate technical change (Krugman 1986; Grossman and Helpman 1990; Romer 1990, Bell and Pavitt, 1992).

A growing body of evidence that is emerging from the developing countries shows first, that there are considerable international variation in the static efficiency with which "given" technologies are used (Pack, 1987) and second but more importantly, there are considerable differences in two types of dynamic efficiency: the intensity with which industrial technologies already used by firms are changed by continuing adaptation, improvement, and development (Bell et al. 1984; Enos and Park, 1988), and the efficiency with which new bases of comparative advantage are created in increasingly technology-intensive industries (Bell and Pavitt 1992). Hence, much emphasis is being placed on analyzing technical change and exploring the policies and institutions most likely to promote such change and improve dynamic efficiency.

Studies have shown that the performance of South-East Asian countries notably described as the Newly Industrializing Countries (NICs) such as Singapore, Taiwan, Hong-Kong, and China have been brought about by building up relatively good technological capabilities in a spectrum of industries compared to international standards and that this was a major factor in their rapid export growth and technological upgrading (Pack and Westphal, 1986; Aw and Batra, 1998; Wignaraja, 2001). In these economies, foreign technology is first adapted for incorporation in new production facilities, at which time the original technology may be improved on or adapted for the specific situation (Amsalem and Michael, 1983), and later modified to conform to changes in input and product markets.

In a rapidly globalising world, the ability of countries, particularly Nigeria to be in the league of the NICs, and possibly catch up with the developed countries lies in the extent to which technology capabilities can be accumulated. While many studies have been carried out on the importance and process of accumulating technological capabilities in developed countries and developing countries generally (Bell and Pavitt, 2003; Enos and Park, 1988), the empirical examination of this area has thus far been somewhat scarce, particular at firm level in Nigeria. Existing studies for instance, Akerele (2003) and Oyelaran-Oyeyinka et al., (2007) have limited focus. First, the studies failed to examine the factors that drive technological capability available in firms. Second, the studies did not decompose technological capability available in firms. Also, the studies failed to examine whether the knowledge and skills in the selected industry has led to any incremental, adaptive or modified new products and processes that can be termed as innovation.

The present study, therefore, intends to bridge these knowledge gaps identified above by focusing on the ICT, a sector often recognised as a ‘strategic’ one on the basis that it exhibits positive externalities with other industries, thus contributing to social and economic welfare. More importantly, existing studies in developing countries including Nigeria do not examine the critical issue of the development of appropriate software to evaluate and review existing technological capability particularly, in the ICT. This is a critical gap in the existing literature, and the present study also intends to bridge this gap.

1.3 Research Questions

The following questions were considered in order to find solutions to the highlighted problems in the ICT industry in Nigeria:

(i) What are the capabilities (potentials and competence) available in the industry?

(ii) What are the factors that determine and influence technological capabilities and technologies in the industry?

(iii) Have the firms been able to master the ICTs enough as to generate innovations?

(iv) How does the technological capability of the firms impact on their performance?

(v) What strategies can be employed to develop technological capability in the industry?

1.4 Objectives of the Study

The general objective is to carry out a study on technological capabilities and innovations in the ICT industry in Nigeria with a view to providing information that would enhance growth and competitiveness in the industry.

The specific objectives of the study are to

(i) examine the existing technological capabilities in selected ICT firms;

(ii) assess the types and degree of novelty of technological innovations that have emanated from the ICT firms in Nigeria;

(iii) investigate the factors influencing technological capability in the industry;

(iv) appraise the impact of technological capabilities on the firms' performance; and

(v) develop a computer software for technological capabilities evaluation and review in the firms.

1.5 Delimitation

The study covered mainly computer firms involved in development/manufacturing and assemblage of computer hardware, accessories and software. The focus is on firm because there is emphasis in literature on manufacturing enterprises as the main actors in the process of accumulating technological capability (Bell and Pavitt, 1993; Wignaraja, 2001). Furthermore, the study focused on technological capability building in the Small and Medium ICT Enterprises because majority of the ICT firms in Nigeria falls into this category – that is having a capital base and investment of more than ₦1.5 Million and employing between 11 and 300 personnel. Finally, time series was introduced into the study to enable the study determine the variation in performance following improvements in the accumulation of the stock of technological capability over time in the industry. Thus, a span of five years (2003-2007) was considered appropriate for the study due to the dynamism of the technologies in the industry with the rate of technical obsolescence much faster than in other technologies such as steel and textiles

2.0 Literature review

ICTs are systemic and pervasive set of technologies. They are associated with fundamental institutional, social and economic restructuring. In developed countries, the diffusion rate of ICTs is very rapid, facilitates human development and produces material benefits. In such countries, ICT contribute to an innovative climate and institutions, adequate supply of skills and finance, disposable income and investment capital, policy intervention among others. However, in many more countries, where the learning, skill and needs of ICT are not adequately explored and given attention, there exist a vicious cycle of absence of innovation, participating in ICTs as consumers only, ICTs being poorly integrated with the rest of the economy and society, lack of skilled people and finance, low levels of income and insufficient policy capability (IBM Corporation, 2007).

The positive benefits of diffusion of ICTs, which include productivity gains, job creation, improvements in wealth, enhancement of well being, are for the most part, limited to wealthy countries. In those countries, the rapid diffusion of ICTs has been facilitated by technological capabilities, economic restructuring in OECD countries, reorganization of firm-level production processes, changes in functioning of markets and social and political change, and through a series of feedback effects, has produced material and social gains (IBM Corporation, 2007).

The need to transform Nigeria into a knowledge-based economy should be motivated by the necessity to develop national capability in ICT. For a knowledge economy, national plans and strategies must relate to improving human resource and skill capability, others include institutional development, incentives, information structure, science and technology capacity, public and private sector reforms and bridging the digital divide (Mohammed, 2005; Ramirez, 2006).

Malaysia in her quest to become a knowledge-based economy undertook the Eighth Malaysia Plan, 2001-2005 and introduced a host of measures, taken from the Knowledge Economy Master Plan. These included the areas of human resource development, research and development, science and technology, venture capital financing, ICT infrastructure, content development, promoting electronic based activities as well as creating a supportive regulatory framework (Mohammed, 2005).

Chinese information and communication technology (ICT) firms have developed in the past 20 years into internationally competitive players and major contributors to their country's industrial development (Ramirez, 2006). To reach this position they have innovated new products that are competitive on the world market. This achievement is particularly significant since China remains a poor country in terms of per-capita income, and other developing countries have failed to make similar breakthroughs. Hence, there is a need to research into how this has been accomplished. Thus, it becomes imperative that a study of this nature would in no doubt contribute to building a knowledge-driven society and address need issues that would position Nigeria into emerging as one of the leaders in ICT development.

This review focus on ICTs around the world; technological capability and industrial development; technological learning; technological change; technological capability in developing countries and enterprises; ICTs industry in Nigeria and innovation; conceptual framework and the underlying theory for the study.

2.1 Information and Communications Technologies (ICTs)

The United Nation Development Programme (UNDP) defines ICTs as basically information-handling tools - a varied set of goods, application and services that are used to produce, store, process, distribute and exchange information. They include the "Old" ICTs of radios, television and telephone and the "new" ICTs of computers, satellite and wireless technology and the Internet. These different tools are now able to work together and combine to form our networked world – a massive infrastructure of interconnected telephone services, standardized computer hardware, internet, radio and television which reaches into every corner of the globe". Hamelink, 1997 also defines ICTs as those technologies that enable the handling of information and facilitate different forms of communication. These include capturing technologies (e.g. camcorders), storage technologies (e.g. CD-ROMS), processing technologies (e.g application software), communication technologies (e.g. wide area networks), and display technologies (e.g. computer monitor). ICTs include old and new technologies that facilitate storage and transfer of information. However the distinction between old and new technologies is no more important as convergence of technologies and media has now made traditional distinctions and classification less useful since radio, television, satellite technologies and the Internet are now being combined in innovative ways to reach a wide range of target audiences. For instance, you can browse the web on your television or from your cell phone, make phone call from your computer, etc.

2.2 Information and Communications Technologies (ICTs) around the World

All sectors of Europe's economy depend on ICTs and they believe in continued heavy investment in ICT research and in bringing innovations to market. The contribution of ICT to the economy of both Europe and America is well established based on empirical evidence from growth accounting models that link the production and use of ICT to productivity (Table 1). From the table, the aggregate productivity in the EU grew by 1.8% per year from 1995 to 2000 with at least 55% of that increase due to ICT. Between 2000 and 2004, productivity growth fell to 1.1% but the contribution of ICT remained high at around 45%. The impact of ICT on productivity in the EU has consistently been only half of the impact in the US over the last ten years. From 2000 to 2004 the relative figures were 0.5% and 0.9%. The US continues to outstrip the EU both in terms of efficiency gains in the ICT sector and in terms of investment in ICT. Furthermore, there is a significant difference in the contribution of ICT to productivity before and after 2000.

Table 1: The ICT Sector and its impact within Europe and the USA

S/no	Indicators	EU	USA
1	Size (% of the economy)		
	2000-2003	5.6%	7.2%
2	Growth (real terms)		
	2000 -2003	5.3%	4.6%
3.	Market Revenue growth (nominal terms)		
	2004	3.8%	3.9%
	Total ICT Sector	3.6%	3.9%
4	ICT Research and Development		
	% all research expenditure	25%	35%
	% GDP	0.31%	0.63%
5.	Investment in ICT		
	As % of GDP	2.4%	4.2%
6.	Labour Productivity		
	2000 – 2004 Total	1.1%	2.8%
	ICT	0.5%	0.9%
	Non-ICT	0.5%	1.9%
7	Innovation by businesses		EU
	ICT-enabled product/services		17%
	Non-ICT-enabled product/services		29%
	ICT-enabled processes		12%

Notes: (1) Size is % value-added at current prices in the EU15 – source: Groningen Growth & Development Center (GGDC) – 60 Industry Database; (2) average annual growth of value added at constant prices in the EU15 – source: GGDC-60 Industry database; (3) annual growth of market value in % - source: EITO 2006; (4) R&D in 2002-2003-source: Commission services; (5) Annual average 2000-2004 - EU15 - source: GGDC- Total Economy Growth Accounting database; (6) average annual growth rates in % - EU15 - source: B. van Ark and R. Inklaar (2005); (7) % of companies having introduced innovations in previous 12 months – EU 15 – source: European Commission -2004 eBusiness W@tch.

Table 2 shows the distribution of ICT specialist businesses by states in the United Kingdom in 1999. New South Wales was the base for 39% of all specialist ICT producing businesses in Australia. Western Australia was the base for 8.5%, with a total of 1,535 specialist ICT businesses - 112 communications services businesses, 1,024 information services businesses, 356 ICT equipment wholesalers, and 43 ICT equipment-manufacturing businesses.

Table 2: 1999 ICT specialist businesses by State in UK

	Comms Services	*Information Services*	*Equipment Manufacture*	*Equipment Wholesale*	*Total*
New South Wales	402	6,362	128	842	7,734
Victoria	249	4,589	116	850	5,804
Queensland	170	1,760	53	415	2,398
Western Australia	*112*	*1,024*	*43*	*356*	*1,535*
South Australia	65	682	35	232	1,014
Australian Capital Territory	32	729	22	104	887
Tasmania	25	111	5	63	205
Northern Territory	18	53	5	34	110
Australia (Total)	869	14,731	294	2,177	18,072

Note: Multi-State businesses are counted in each State in which they operate, hence State totals do not sum to national total.
Source: Houghton, J.W. (2001) *Information Industries Update 2001*, CSES, p. 32, see www.cfses.com.

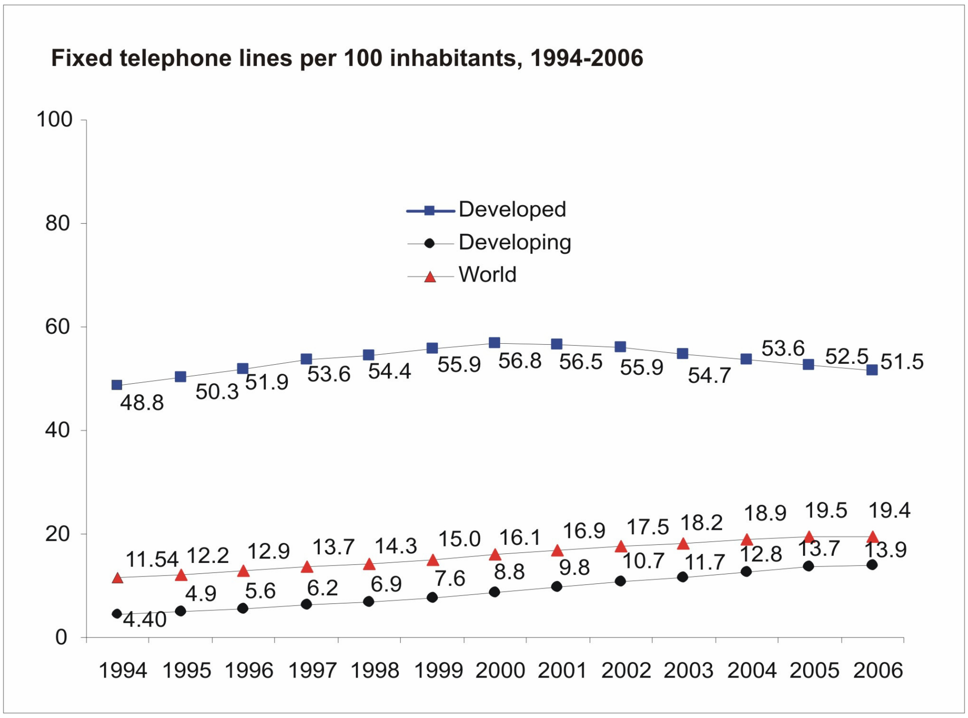

Figure 1: Fixed line penetration rates worldwide and for developed and developing regions, between 1994 and 2006

Source: ITU ICT Statistics 2007

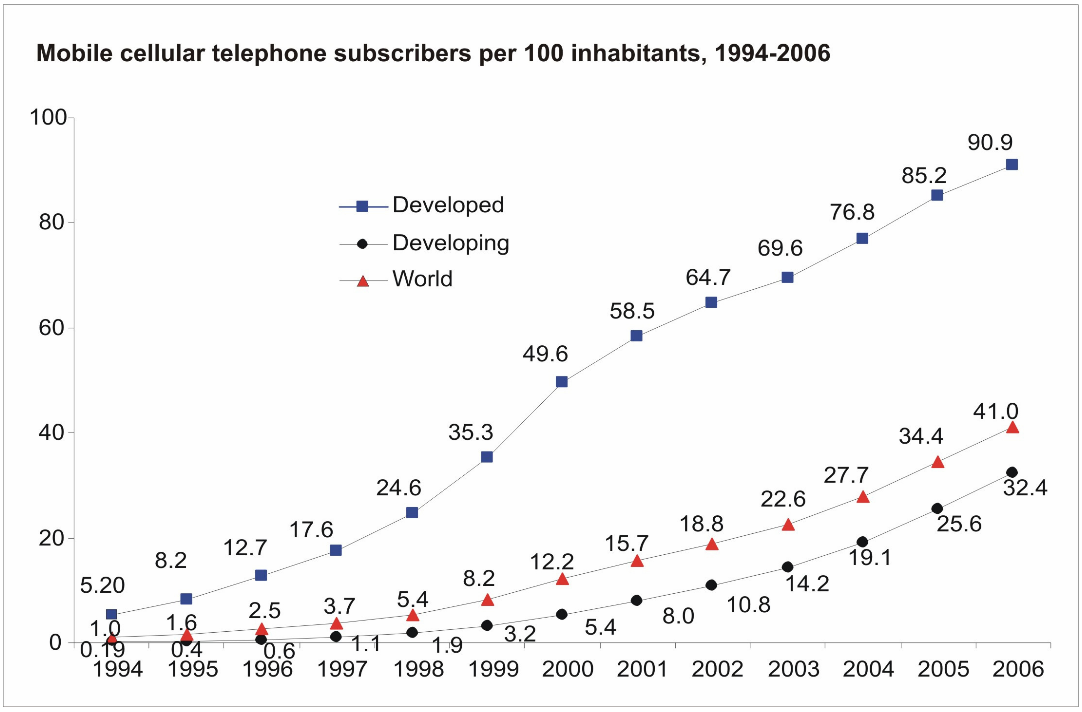

Figure 2: Mobile cellular penetration rates worldwide and for developed and developing regions, between 1994 and 2006

Source: ITU ICT Statistics 2007

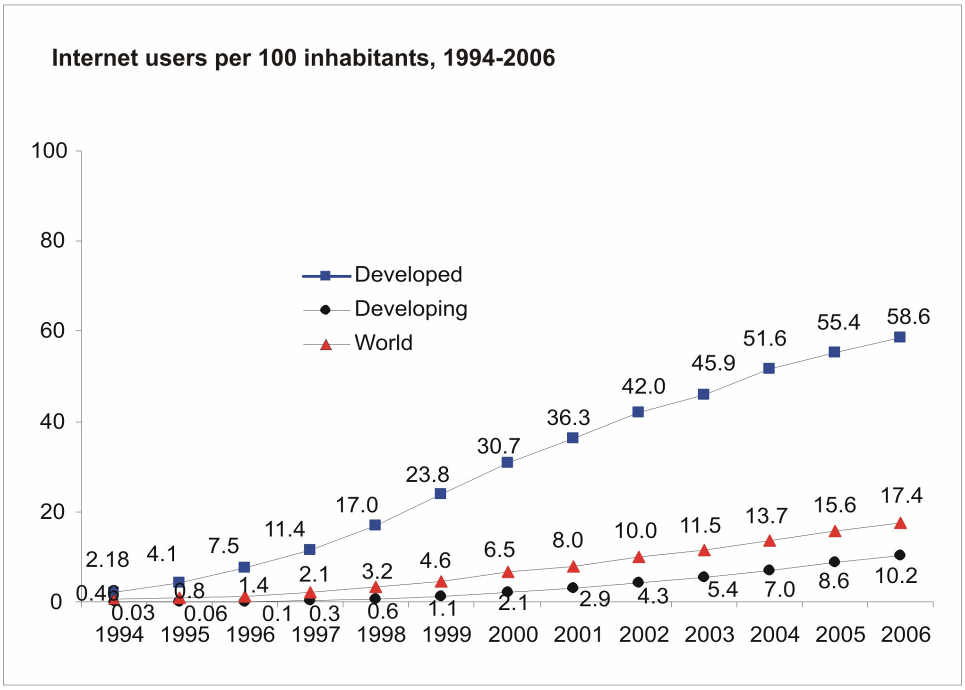

Figure 3: Internet user penetration rates worldwide and for developed and developing regions, between 1994 and 2006

Source: ITU ICT Statistics 2007

In general, the telecommunication/ICT sector has undergone major changes in recent years with higher growth in the mobile sector. ITU data suggest that the number of mobile cellular subscribers surpassed the 3 billion mark in August 2007. In 2006, less than 5 out of every 100 Africans use the Internet, compared with an average of 1 out of every 2 inhabitants of the G8 countries (Canada, France, Germany, Italy, Japan, Russia, the UK and the US). There are roughly around the same total number of Internet users in the G8 countries as in the rest of the world combined: 474 million Internet users in G8 countries and 657 million Internet users in non-G8 countries. The G8 country which is just 13% of the world's population has more than 40% of the world's total Internet users and 28% of the world's total mobile users.

In Africa, the use of ICTs has grown relatively rapidly in most urban areas. Some years back, only a handful of countries had local Internet access, now it is available in every capital city. In the same period more mobile cell phones were deployed on the continent than the number of fixed lines laid in the last century. Hundreds of new local and community radio stations have been licensed, and satellite TV is now also widely available. However, the Digital Divide is still at its most extreme in Africa, where the use of ICTs is still at a very early stage of development compared to other regions of the world. According to the report by ITU and UNESCO statistics, of the approximately 816 million people in Africa in 2001, it is estimated that only 1 in 4 have a radio (205m), 1 in 13 have a TV (62m), 1 in 35 have a mobile phone (24m), 1 in 40 have a fixed line (20m), 1 in 130 have a PC (5.9m), 1 in 160 use the Internet (5m), and 1 in 400 have pay-TV (2m). As shown in Table 3 below, sub-Saharan Africa, along with South Asia, remain at the bottom of the list of developing regions in Internet usage surveys around the world, while South Asian Internet use is growing more rapidly.

Table 3: Internet users as percentage of total population

Region	**1998**	**2000**
United States	26.3	54.3
High-income OECD (excl.US)	6.9	28.2
Latin America and the Caribbean	0.8	3.2
East Asia and the Pacific	0.5	2.3
Eastern Europe and CIS	0.8	3.9
Arab States	0.2	0.6
Sub-Saharan Africa	0.1	0.4
South Asia	0.04	0.4
World	2.4	6.7

Source: UNDP World Development Report 2001

As far as specific ICTs are concerned in Africa, most literatures would talk on adoption and permeations rather than technology innovations and development in the sector. For instance in broadcasting, Jensen 2002, talked on the massive adoption and usage of radio and satellite-based broadcasting popularly known as the DSTV in Africa. He stated that radio ownership in Africa was estimated by UNESCO at close to 170 million with a 4% per annum growth rate in 1997 and estimates for 2002 was put at about over 200 million radio sets, compared with only 62 million TVs. For telecommunications, the number of fixed lines was said to have increased from 12.5 million to 21million across Africa between 1995 and 2001. North Africa had 11.4 million of the lines; South Africa had another 5 million lines, leaving only 4.6 million for the rest of the continent. For computer hardware and software development, up until 2001, there had been a prevailing high cost of computer hardware, which constitutes the largest component of many startup budgets in the continent. Although, cost are becoming lower due to the emergence of local hardware producers and low-cost bandwidth is becoming increasingly available, such as through Ku-Band VSAT and spread spectrum wireless (WiFi) links. Nonetheless, local producers are still very few and as a result increasing attention is being directed toward the use of recycled PCs, thin clients, set-top boxes, or other low-cost Internet 'appliances', and Open Source (free) software.

Table 4 below shows Africa ICT indicators in 2007. Obviously, the numbers of main telephone lines have increased from 21 million in 2001 to almost 35.5 million in 2007. North Africa had 18.6 million of the lines; South Africa had another 4.6 million lines, leaving 12.3 million for the rest of the continent. Mobile subscribers as a percentage of total population in Africa as at 2007 are 27.5% while internet users are 5.3%.

Table 4: Africa ICT Indicators for 2007

	Population	Main telephone lines		Mobile subscribers		Internet users	
	000s	000s	p. 100	000s	p. 100	000s	p. 100
Algeria	33'860	2'922.7	8.63	21'446.0	63.34	3'500.0	10.34
Egypt	75'500	11'228.8	14.87	30'047.0	39.80	8'620.0	11.42
Libya	6'160	*852.3*	*14.56*	4'500.0	73.05	*260.0*	*4.36*
Morocco	31'220	2'393.8	7.67	20'029.0	64.15	7'300.0	23.38
Tunisia	10'330	1'273.3	12.33	7'842.0	75.94	1'722.2	16.68
North Africa	**157'070**	**18'670.9**	**11.91**	**83'865.0**	**53.39**	**21'402.2**	**13.64**
South Africa	48'580	4'642.0	9.56	42'300.0	87.08	*5'100.0*	*10.75*
South Africa	**48'580**	**4'642.0**	**9.56**	**42'300.0**	**87.08**	**5'100.0**	**10.75**
Angola	17'020	*98.2*	*0.62*	3'307.0	19.43	*95.0*	*0.60*
Benin	9'030	110.3	1.22	1'895.0	20.98	150.0	1.66
Botswana	1'880	*136.9*	*7.78*	1'427.0	75.84	*80.0*	*4.55*
Burkina Faso	14'780	*94.8*	*0.70*	1' 611.0	10.90	*80.0*	*0.59*
Burundi	8'510	*35.0*	*0.45*	250.0	2.94	*60.0*	*0.77*
Cameroon	18'550	*130.7*	*0.79*	4'536.0	24.45	*370.0*	*2.23*
Cape Verde	530	*71.6*	*13.80*	148.0	27.9	*33.0*	*6.36*
Central African Rep.	4'340	*12.0*	*0.29*	130.0	2.99	*13.0*	*0.32*
Chad	10'780	*13.0*	*0.13*	918.0	8.52	*60.0*	*0.60*
Comoros	840	*19.1*	*2.33*	40.0	4.77	*21.0*	*2.56*
Congo	3'770	*15.9*	*0.40*	1'334.0	35.40	*70.0*	*1.70*
Côte d'Ivoire	19'260	*260.9*	*1.41*	7'050.0	36.6	*300.0*	*1.63*
D.R. Congo	62'640	*9.7*	*0.02*	6'592.0	10.52	230.4	0.37
Djibouti	830	*10.8*	*1.56*	45.0	5.40	*11.0*	*1.36*
Equatorial Guinea	510	*10.0*	*1.99*	220.0	43.35	*8.0*	*1.55*
Eritrea	4'850	*37.5*	*0.82*	70.0	1.44	*100.0*	*2.19*
Ethiopia	83'100	880.1	1.06	1'208.0	1.45	291.0	0.35
Gabon	1'330	*36.5*	*2.59*	1'169.0	87.86	*81.0*	*5.76*
Gambia	1'710	76.4	4.47	796.0	46.58	100.2	5.87
Ghana	23'480	376.5	1.60	7'604.0	32.39	650.0	2.77
Guinea	9'370	*26.3*	*0.33*	*189.0*	*2.36*	*50.0*	*0.52*
Guinea-Bissau	1'700	4.6	0.27	296.0	17.48	*37.0*	*2.26*
Kenya	37'540	264.8	0.71	11'440.0	30.48	*2'770.3*	*7.89*
Lesotho	2'010	*53.1*	*2.97*	456.0	22.71	*51.5*	2.87
Liberia	3'750	...	...	563.0	15.01	...	...
Madagascar	19'680	133.9	0.68	2'218.0	11.27	*110.0*	0.58
Malawi	13'930	175.2	1.26	1'051.0	7.55	139.5	1.00
Mali	12'340	85.0	0.69	2'483.0	20.13	100.0	0.81
Mauritania	3'120	*34.9*	*1.10*	1'300.0	41.62	*30.0*	*0.95*
Mauritius	1'260	*357.3*	*28.45*	936.0	74.19	*320.0*	*25.48*
Mozambique	21'400	*67.0*	*0.33*	3'300.0	15.42	*178.0*	*0.90*
Namibia	2'070	138.1	6.66	800.0	38.58	101.0	4.87
Niger	14'230	*24.0*	*0.17*	900.0	6.33	*40.0*	*0.28*
Nigeria	148'090	6'578.3	4.44	40'396.0	27.28	10'000.0	6.75

Rwanda	9'720	*16.5*	*0.18*	679.0	6.98	*100.0*	*1.08*
S. Tomé & Principe	160	7.7	4.86	30.0	19.09	23.0	14.59
Senegal	12'380	269.1	2.17	4'123.0	33.31	820.0	6.62
Seychelles	90	20.6	23.79	77.0	89.23	*29.0*	*35.67*
Sierra Leone	5'870	...	...	776.0	13.23	*10.0*	*0.19*
Somalia	8'700	100.0	1.15	600.0	6.90	*94.0*	*1.11*
Sudan	38'560	345.2	0.90	7'464.0	19.36	1'500.0	3.89
Swaziland	1'140	*44.0*	*4.27*	380.0	33.29	*42.0*	*4.08*
Tanzania	40'450	236.5	0.58	8'252.0	20.40	*384.3*	*1.00*
Togo	6'590	*82.1*	*1.30*	1'190.0	18.08	*320.0*	*5.07*
Uganda	30'880.0	162.3	0.53	4'195.0	13.58	2'000.0	6.48
Zambia	11'920	91.8	0.77	2'639.0	22.14	500.0	4.19
Zimbabwe	13'350	344.5	2.58	1'226.0	9.18	1'351.0	10.12
Sub-Saharan	**757'880**	**12'098.3**	**1.65**	**138'310.0**	**18.28**	**23'904.2**	**3.23**
AFRICA	**963'530**	**35'411.2**	**3.77**	**264'475.0**	**27.48**	**50'406.4**	**5.34**

Source: ITU World Telecommunication/ICT Indicators Database (2008)

2.3 Technological Capability and Industrial Development

Technological capability has been diversely defined in three broad ways: as input to economic activities; as an output of economic activities; and as both an input and output. The definitions of technological capability as an input to economic activities dwell on contributions of technological capability to economic activities at various levels of economic organisation. In this train of thought, the International Labour Office (1986) defined technological capability as ‘the ability of a country to choose, acquire, generate and apply technologies which contribute to meeting its development objective’. With a particular focus on developing countries as importers of technologies, Aw and Batra (1998) as cited in Olamade (2002) described technological capability as the ability to adapt or assimilate technology imported from abroad and to incorporate the additional and distinct resources needed to manage and put to productive use the newly acquired technology. Furthermore, as an input, technological capability is the resources (or knowledge assets) needed to generate and manage production-based and innovative activities such as improvements in processes and production organisation, products, equipment, and engineering projects (Figueiredo, 2007). These are accumulated and embodied in individuals (skills, expertise, and experience) and organisational routines and systems.

As an output, technological capability was defined in terms of its constituents. Girvan (1981) and Enos (1992) following this approach defined technological capability in terms of a complex mix of three components. These components are: (i) The existence of people with a scientific foundation/training in the basic concept of knowledge relevant to a particular area of concern; (ii) The possession by these people of a certain amount of operational experience, and; (iii) The existence of an organisation in which the skills are resident and which can harness and deploy them in pursuit of given goals.

As both an input and output, Lall (1994) defined technological capability as critical assets – human and organisational capitals that are employed by productive enterprises for the efficient use of machinery, equipment and technologies. Similarly, Bell and Pavitt (1993) defined technological capability as the resources needed to generate and mange technical change. These resources include skills, knowledge, experience as well as particular kinds of institutional structure and linkages necessary to produce inputs for technical change.

Thus, technological capability goes beyond the trilogy of science, engineering and technology. It includes organisational know-how, knowledge of behavioural patterns of workers, suppliers and customers (Bamiro, 1997). This knowledge and skills are evolutionary; it includes iterative serendipity known as trial and error, cumulative learning-by-doing and by-using and by-interactions within a firm; between a firm and its suppliers and between a firm and its customers.

Technological capabilities are in general tacit, firm and sector specific. Its accumulation is one of the factors that help to explain the success or failure of countries technologically and economically throughout history. The industrial development of nations depends on the ability of individual enterprises who are key players to develop and sustain technological capabilities and remain competitive in doing so – Industrial Development Report (IDR) 2002. In economic development debates, a need assessment of domestic technological capability building and private sector development usually ensue. Technological capabilities are at the centre of the new theories of economic growth which focus on technology and human capital as engines of growth (Romer 1986; Stokey 1988; Young 1991). Recent developments in this literature suggest that long-run economic growth, as seen in East Asia most recently, reflects sustained increases in firm productivity stemming from continuous accumulation of technological capabilities (Biggs et al., 2001). Building technological capabilities requires conscious technological and innovative effort.

The accumulation of technological and innovative capabilities is a key factor for developing countries to achieve world leading positions in different industrial sectors either by catching up with the international technological frontier (e.g. South Korea in steel, automobiles, and semi-conductors) or by engaging in brand new technological trajectories (e.g. Brazil in oil exploration in ultra-deep waters, forest biotechnology for pulp and paper, and bio fuels) Bell and Pavitt, 1993.

For decades, many nations have achieved industrial development not only by developing technology but also by utilising their capability in technology transfer and reengineering. Industrial development is a process of acquiring technological capabilities and translating them into product and process innovations in the course of continuous technological change (Kim and Nelson, 2000). Technological capability building enables core competency to be developed in industry. It can be regarded as an indispensable mechanism for strengthening competitiveness in old and thriving firms and for developing competitiveness in latecomer firms. Technological capability building is regarded as a tool for developing and strengthening the competitiveness of a nation (Sikka, 1999). A major objective of technological capability building is to accumulate technical knowledge that would enable firms to develop commercially exploitable product and processes, to win new markets or to hold existing ones against competition, and to reduce costs of production (Central Advisory Council for Science & Technology, 1968). In recent years, technological capability building has been a well researched area and has been increasingly recognized as a driver for economic growth (Yeh and Chang, 2003).

The UNIDO (2004) industrial development report considered technological capabilities as crucial to national economic performance – all the more so due to the introduction of stronger Intellectual Property Rights (IPRs), regulatory harmonisation and standardisation and the worldwide spread of emerging science-based industrial technologies. Developing countries' prospects for catching-up with more advanced countries in productivity and income hinge increasingly on their ability to rapidly build up competences. This places domestic knowledge systems at the core of industrial development strategies. This is not new, but has acquired far greater importance in recent times.

Among firms, small enterprises are better suited to develop their technological innovations due to their specific advantages of flexibility, concentration and internal communications (Rothwell and Zegveld, 1982). Thus, as good and dynamic as ICTs are, it is not just its presence in a country that matters but the ability of the firms in the sector to build technological capabilities and competences that can catapult the industry and serve as motor for industrial growth and development.

The Nigerian industrial sector is made up of both private and public firms as well as the multinationals. Sometimes it is being described as the formal sector. It probably contributes about 3 percent to Nigeria's Gross Domestic Product (GDP), Ogbimi (2000). It is highly import dependent with each market made up of few firms having little or no basis for competition. The catalytic role that this sector would have played in the development of the country's economy are being hampered by unstable power supply, high interest rates, dumping of imported cheap products, multiple taxation and uncompetitive prices (Aderemi et al., 2008)

Technological capability would mostly be adaptive and incremental in nature within the Nigerian industrial sector. This is because of the presence of constraints which are peculiar to developing countries such as poor infrastructure and weak innovation systems. Nigeria's industrial sector like most of other developing countries especially in the sub-Saharan Africa has gone through a lot of challenge. Current issues of globalization, trade liberation and competitiveness has helped to boost the challenges. Prior to the 1970's, researchers were of the opinion that large enterprises were the cornerstone of a modern economy. However, this view has changed, as the importance of small-scale manufacturing industries in promoting industrialization and economic growth has been recognised globally. Thus, industrialisation, through not only small scale industries but also cottage/micro industries remains a catalyst for technological, financial and other socio-economic transformation.

2.4 Technological Learning

Technological learning is a process that permits companies, industrial sectors and countries to accumulate their own capabilities to carry out production-related and diverse types and levels of innovative activities over time. Industrialised economies attain industrialization through the process of technological learning. Technological learning is not necessarily a conscious or intentional process (Hubber, 1991). Dodgson (1993) described technological learning as the way firms build, supplement and organise knowledge and routines around their activities and within their culture, and adapt and develop organisational efficiency by improving the use of the broad skills of their workforce. Ernst et al (1994) distinguished three types of learning. Formal learning leading to certificates, degrees and diplomas. Non-formal learning such as on-the-job training, collaboration, or learning externalities, and informal training which is a life long process by which employees in foreign affiliates or in domestic companies interact with Trans-National Corporations (TNCs) and acquire values, attitudes and beliefs embedded in the organisational culture of the TNCs through daily experience, observation and exposure to indoctrination. According to Biggs et al (1995) technological learning is facilitated by firms' involvement in information-rich environment created by a dense network of relations with other firms engaged in similar activities, with training opportunities and information sources that address specific business problems, and with an available network of specialised consultants. Technological learning and the strategy for approaching it therefore becomes crucial for firms that have to operate imported technology. Since industrial dynamism and competitiveness depend largely on the accumulation of technological capabilities, Bell and Pavitt (1993) refer to any process that strengthens those capabilities as technological learning. Albu (1997) described technological learning as a process involving conscious effort. This was because studies of infant industries in the South (e.g. Bell *et al.* 1982) demonstrated that learning does not occur spontaneously, and that performance can easily stagnate or decline over the long-run. Akerele 2003 defined technological learning as any process that strengthens the technological capabilities for generating and managing technical change. Firms that manage to master technology and initiate a process of incremental innovation, do so as a result of learning. Lall (1987) accrue the industrialisation of older industrial firms to their investments in technological knowledge and innovations.

There are two categories of learning as identified by Bell and Pavitt (1993). The first refers to the methods by which an individual firm or economy accumulates a set of skills through education, training and experience which can be by hiring of skills and the well-known 'learning by doing'. The second category is technical change which sometimes is used interchangeably with learning in literature. However, technical change does not occur in isolation of learning alone but with other inputs. Lall (1989) as cited in Akerele (2003) suggests three sub-categories of learning namely: (i) elementary learning which involves 'learning-by-doing' and learning by adapting'; (ii) intermediate learning consisting of 'learning-by-design' and learning-by-improved design' and; (iii) advanced learning also referred to as 'learning-by-setting up a complete production system'.

The role of technological learning cannot be overemphasized as it is the way by which firms acquire and build up technological knowledge and core competences. Also, learning represents the dynamic component of the process of acquisition of capabilities (Oyeyinka 1994) and is brought about through the following broad channels: (i) the apprenticeship system of training; (ii) on-site training at supplier's factory; (iii) on-the-job training within the country; (iv) expert contracting; (v) support mechanism provided by public institutions; (vi) learning-by-doing production and maintenance and; (vii) learning through transactions with local and external agents.

Furthermore, Biggs et al (1995) underscores the elements of the process of skill acquisition in firms to include (i) learning by doing – this refers to on-the-job skill acquisition by carrying out tasks in the production process; (ii) learning through training – this has to do with transmission of skills and further improvement during periods explicitly set aside for these purposes; (iii) learning from changing – this is involved with the introduction of innovative technical change-attempts to adapt, diversify, improve quality and bring out new products or variants of production processes; (iv) learning by evaluation – here, there is regular monitoring of changes and performances in production; (v) learning by hiring- where consulting services and taking of specialist advice outside the enterprise exists and; (vi) learning by searching scientific research applied to production.

Technological learning has been linked to the industrialization of countries by a host of authors (Kim, 1997; Oyeyinka, 1997; Biggs et al, 1995; Akerele, 2003; Bell and Pavitt, 1993, Lall, 1987; Akinbinu, 2001). For instance, Kim, (1997) cited in Akinbinu (2001) described a stage model of how South Korea acquired, absorbed and assimilated imported technology (Table 5). He purported that with some modifications, the model may be used to explain the industrialization process in most of the successful New Industrialized Countries (NICs). At the level of the firm, Table 6 shows the typology of learning and capabilities that successful nations acquired in a roughly sequential order. The search starts with the mastery of production and maintenance techniques. Higher levels of technological capabilities follow with experience and explicit investment in training and learning. Many firms try to acquire only those that contribute to their commercial objectives.

Table 5: Pattern of Technological Capability Building in Developing Countries

Learning Phases	First Stage	Second Stage	Third Stage	Fourth Stage
Preparation	Poaching experienced personnel, literature review, observation tour	Literature review, observation tour, foreign personnel	Literature review, observation tour	Poaching scientists, literature review
Acquisition	Packaged technology transfer, foreign personnel	Unpackaged technology transfer	Unpackaged technology transfer	Acquisition by research, overseas R&D, foreign personnel
Assimilation	Learning-by-doing	Learning-by-doing	Learning-by-doing	Learning-by-doing
Improvements/ Application	Learning-by-doing	Learning-by-doing	Learning-by-doing	Learning-by-doing

Source: Linsu Kim (1997) cited in Ajibayo Akinbinu (2001)

Table 6: A Typology of Technological Learning and Capability Acquisition

Technological Capability	Required Technological Learning
Production and maintenance capabilities	Leaning –by-doing Process, production, management, engineering repair and maintenance
Investment capability	Learning by: bargaining and project identification, doing detailed design, setting up and commissioning plants, modernizing existing plants
Minor change capability	Learning the: ability to adapt and improve continuously, incremental upgrading of product design and process technology
Strategic marketing capability	Learning by accumulating: knowledge and skills for collecting market intelligence, for development of new markets and for establishing distribution channels and customer services
Linkage capability	Learning by accumulating: knowledge and skill and organisational competence to transfer technology within firms, between firms and within a firm and the domestic science technology and engineering infrastructure
Major change capability	Learning by accumulating: knowledge and skills for creating major changes in the design and core features of products and products and production process. It is the llearning that culminates in the creation of new technologies.

Source: Oyelaran-Oyeyinka, B. Technological learning in African Industry: A Study of Engineering Firms in Nigeria. Science and Public Policy, 1997, UK cited in Akinbinu A. 2001

The learning process therefore covers a much wider range of knowledge and operations than innovation does. Sethuraman and Maldonado (1992) opined that learning mechanisms are made up of dynamic elements of technological capabilities which enable the firms to change over time the levels of investment and production capabilities. These involve acquisition of new investment and production capabilities or improving those already existing in the firms which are crucial for the firm's future competitive success and survival. These learning mechanisms can ultimately determine parameters and aggregate manufacturing productivity growth and development (Akerele, 2003).

In the views of Biggs et al (1995), while the incidence of training appears lower in Africa in comparison with other regions of the world, the inter-firm and inter sectoral patterns are similar. Enterprise size is an evident determinant of firm-based training in Africa as it is obtained in the rest of the world. Empirically in semi-industrialised countries like Taiwan, 38% of large firms formally train workers in-house while the corresponding figures for small firms is only 4%. In Zimbabwe, the corresponding figures are 52% for large firms and 17% for small firms. In Kenya, 34% for large and 12% for small. Also in Japan large firms have about 18% of their employees engaged in in-house, on-the-job training programmes and 30% engaged in in-house, off-the-job training programmes. The small firms have about 8% of their employees involved in in-house, on-the-job training and 24% in in-house, off-the job training (Biggs et al 1995).

In terms of who actually receives the training, Bartel (1991), states that in the U.S., workers who receive enterprise training are primarily technical and managerial workers and that non-technical workers receive more training in Europe and Japan than the U.S. This study intends to show whether the formal education received on ICT in Nigerian tertiary institutions is adequate to meet the technological capability requirements in the ICT industry. Furthermore, the study would show the informal learning process of workers; and what categories of workers undergo such informal training in the ICT industry in Nigeria whether they compare with what obtains in newly industrialising nations of the world. This we hope would enhance enterprise level studies on technological capability in Nigeria ICT industry.

2.5 Concept of Technological Change

Technological change is an improvement in process or product occurrence that brings about modernization in the way things are done. It has impact both on individuals and the society. According to Girifalco (1991), technological change generally focuses on the techniques, their attendant devices, products and processes, and the effects of these on individuals and society. It is a dynamic process that encompasses an enormous array of events, influences, motivations, individuals, and institutions. It is regarded as a process because it takes place in time as a series of linked events. Technological change is easier to observe and recognize than to define. For instance if a device, a product or process, which did not exist at some given time is found to exist at a later time, then technological change has taken place. Also, if a device, product, or process is found to be different at two different times, then technological change has occurred over the intervening time period. For this definition to apply, the device, product or process must be a recognizable entity with a sufficient number of constant characteristics so that it preserves its identity over time in spite of the changes it exhibits.

2.5.1 The Three Eras of Technological Change

Girifalco (1991) divided the time sequence of technological change into three broad era namely; invention, innovation and diffusion. Invention is the process of arriving at an idea for a device, product or process and demonstrating its feasibility. While the process of invention would necessarily involve tapping from a reservoir of experience, imagination and knowledge, the outcome satisfies some human or physical need and desire. Innovation is the process by which the invention is first brought into use. It involves the improvement or refinement of the invention, the initial design and production of prototypes, pilot plant testing and construction of production facilities.

The third era, which is diffusion, is the process of the spread of the innovation into general use whereby it is adopted by more and more users.

The three eras of technological change usually overlap and may extend over considerable periods of time. Nonetheless, they are distinct in nature and dates can be attached to the differing eras. Thus, the date of an invention is defined as the time of first publication through an accessible medium such as a technical journal, patent disclosure, and conference of professional bodies or press news. The date of an innovation is said to be the first time it is available for use. For product innovation, this would be the first time it was sold or when production commenced. For process innovation, this would be the first time it is used in regular production runs and for a device; it would be the first time of its development. The era of diffusion commenced at innovation till afterwards. These eras are not static as improvements are continuous. Every improvement upon existing invention, innovation or diffused product, process or device with distinctive features and characteristics could also be regarded as a technological change. Thus, because of the complexity of the matter, there could be no simple precise definition of the process of technological change that applies universally. However, this complexities gives birth to two major types of technological change namely; incremental and radical technological change.

Much literature and available statistics are based more on diffusion of ICT than on invention or innovations – be it radical or incremental. This study shall research mainly into innovations in ICT firms.

2.6 Technological Capabilities in Developing Countries

As discussed in Wignaraja, 2001, a common perception in the literature is that the successful accumulation of technology in a given developing country can be encouraged by a smooth inflow of new information, ensuring conducive macroeconomic conditions and increasing expenditures on education. Though these factors have a role to play, they are insufficient on their own to ensure a continuous process of domestic technological development in developing countries. A comparatively recent development in the literature is the emphasis on manufacturing firms as the main actors in the process of accumulating technological capabilities. Technological Capability literature (Pack and Westphal, 1986; Katz, 1987; Lall, 1992; Bell and Pavitt, 1993; Ernst, Ganiatsos and Mytelka 1998 and Metcalfe) emphasises the notion that enterprises have to undertake conscious investments to convert imported technologies into productive use. New technologies have a large person embodied information otherwise known as tacit element which is difficult to articulate and can only be acquired through experience and deliberate investments in various inputs such as training, information search, engineering activities and research and development (R&D).

The neoclassical approach on technological capability rests on a particular conceptualization of technology at the enterprise level. It assumes that technology is freely available from a known 'shelf' on which there is full information. Firms optimize by choosing from this shelf according to their factor and product prices. Any intervention is necessarily distorting resource allocation. The selected technology is absorbed costlessly and risklessly by the enterprise and used at efficient ('best practice') levels. As a necessary consequence, no learning is required and the underlying assumption is that any observed industrial inefficiency is due to government interventions. In contrast, the evolutionary approach of Nelson and Winter (1982) on technological capabilities draws upon and locates learning in markets as prone to imperfections, satisfying behaviour and widespread failures. It is an approach that intentionally looks at developing countries and formulates a theory of innovation and learning. Among the main contributions to this approach, see Bell and Pavitt, 1993 and 1995, Dahlman et al., 1987, Enos, 1991, Fransman and King, 1984, Figuereido, 2001, Katz, 1987, Lall, 1992, 1993 and 2001, Pack and Westphal, 1986, Pietrobelli, 1994, 1997 and 1998, Wignaraja, 1998.

Technological capabilities are the skills - technical, managerial or organizational - firms need to utilize efficiently the hardware (equipment) and software (information) of technology, and accomplish any process of technological change. Capabilities are firm-specific, institutional knowledge made up of individual skills and experience accumulated over time. Technological change is the result of purposeful activities undertaken by firms ("Technological Efforts"). It is neither exogenous nor automatic. Individual effort is required to make the many tacit elements of technology explicit, and most technological effort does not take place at the frontier of technology at all. It covers a much broader range of effort that every enterprise must undertake to access, implement, absorb and build upon the knowledge required in production. Technology cannot simply be transferred to a developing country or to a firm like a physical product: its effective implantation has to include important elements of capability building. Simply providing equipment and operating instructions, patents, designs or blueprints does not ensure that the technology will be effectively utilized. Substantial efforts to improve technical skills, acquire the necessary equipment and relevant knowledge are continuously needed. Learning plays a central role in this approach, and its success depends on the efficacy with which markets and institutions function, uncertainty is coped with, externalities tapped, and coordination achieved. If the learning period, costs, uncertainties and leakages are very high, coordination with other firms in the supply chain exceptionally difficult, or information, labour and capital markets particularly unresponsive, 'difficult' knowledge may not be absorbed – even where it would be efficient to do so.

Following Lall (1990, 1992 and 2001) a useful categorisation of TC considers the functions they perform and the degree of complexity as the two classificatory principles (The complexity and the variety of TCs does not pretend to be portrayed exhaustively here. Other categorisations have been proposed by Bell and Pavitt, 1995, Dahlman *et al.,* 1987, Enos and Park, 1988, Figueredo, 2002, Katz, 1987). Thus, it is possible to single out "investment", "production" and "linkage" capabilities. When industries are started, many of the TCs necessary at the firm-level are absent. These missing TCs may be temporarily obtained at home or imported in an "unbundled" form, but some "core" capabilities have to be developed by firms and expanded over time. Moreover, many of these TCs are inter-related and partly over-lapping, and there is often strong inter-dependence among them

Investment capabilities refer to all the skills required before the investment is undertaken and needed to carry it out. They include the capabilities to assess the feasibility and profitability. of a project, to define its detailed specification, the technology required and the selection of its best sourcing, the negotiations of the purchase (cost and terms), the skills to erect the civil constructions and the equipment, to draw its detailed engineering, to recruit and train the skilled personnel required, and eventually to design the basic process and supply the equipment.

Production capabilities include the skills necessary for the efficient operation of a plant with a given technology, and its improvement over time. Process, product and industrial engineering capabilities are part of this subset. Among the infinite number of operations that require adequate skills are: the assimilation of process and of product technology, their adaptation and improvement, trouble-shooting, quality control, equipment stretching, workflow scheduling, inventory control, monitoring productivity and co-ordination of different production stages and departments, finally process and product innovations following basic research activity.

Linkage capabilities are required because of high transaction costs; in narrow and inefficient markets, the setting up of extra-market linkages often corresponds to an efficient and rational strategy. Therefore special skills are needed to establish technology linkages among enterprises, between them and service suppliers, and with the science and technology infrastructures.

In each group there are TCs with different degrees of technological complexity. These are used for "routine", "adaptive and replicative", or "innovative and risky" activities. Different levels and depth of technological capabilities indeed explain different levels of industrial performance across countries (Lall, 1990, Pietrobelli, 1998). However, the approach does not presume that all firms will necessarily build up capabilities in a linear sequenced process, neither does it imply that firms will start and end at the same stages (Figueiredo, 2006).

The policy implications of this approach are straightforward: policies need to adopt a firm level focus, and must target the building and strengthening of technological capabilities. Clusters, (global) value chains, production networks or other forms of industrial organization may contribute to a different extent in different circumstances, but firm-level efforts to build and improve TCs are the *sine qua non* of industrial development (Lall, 2001).

2.6.1 Features of Technological Capability in Developing Countries

The need for technological capability, learning and innovation exists in developing countries even when the technology is imported and the seller of the technology provides guidance and assistance on usage. However, the extent and costs of learning vary by technology, enterprise and country. Building technological capability that could lead to technological innovation and competitiveness calls for conscious, purposive and incremental efforts to collect new information, try things out, create new skills and operational routines and forge new external relationships. This process is distinctively different from textbook depictions of how technology is transferred and used in developing countries. The nine most important features of technological capability development as discussed by Figueiredo, 2007 are:

1. Conscious and purposive: Learning is a real and significant process. Vital to industrial development, innovation and learning are primarily conscious and purposive rather than automatic and passive.

2. Risky and costly: Enterprises do not have full information on technical alternatives. Instead, they function with imperfect, varying and rather hazy knowledge of technologies they are using. As a result, there is no uniform, predictable learning curve. Each enterprise has a different innovation and learning experience, depending on its initial situation and subsequent efforts. Each faces an element of risk, uncertainty and additional cost in innovation and learning.

3. Not obvious: Enterprises may not know how to build up the necessary capabilities. In a developing country, knowledge of traditional, stable and simple technologies may not be a good base for knowing how to master modern technologies. So, enterprises may not be able to predict if, when, how and at what cost they would learn enough to become fully competitive, even if the technology is well known and mature elsewhere. This adds to the uncertainty and risk of the learning process.

4. Path-dependent: Firms cope with these conditions by developing organizational and managerial routines, which they adapt over time as they collect new information, learn from experience and imitate other firms. So, technological trajectories tend to be path-dependent and cumulative. Once embarked on, they are difficult to change suddenly (for countries and for enterprises), and patterns of specialization tend to persist over long periods.

5. Highly specific: The innovation and learning process is technology specific, since technologies differ in their learning requirements. For instance, some technologies are more embodied in equipment while others have more tacit elements. Process

technologies (like chemicals or paper) are more embodied than engineering technologies (machinery, automobiles or electronics), and demand different (often less) effort. Capabilities built in one manufacturing activity may not be easily transferable to another and policies to promote innovation and learning in one may not be very useful in another. Similarly, different technologies can involve different breadth of skills and knowledge, with some needing a relatively narrow range of specialization and others a very wide range.

6. Many complex inter-linkages: Technological innovation and learning in a firm do not take place in isolation: the process is prevalent with externalities and inter-linkages. The most important direct interactions are with suppliers of inputs or capital goods, competitors, customers, consultants and technology suppliers. Technological linkages also occur with firms in unrelated industries, technology institutes, extension services and universities, industry associations and training institutions. Many such linkages take place informally and are not mediated by markets. Not all are deliberate or cooperative: some learning involves imitating and stealing knowledge. Where information and skills flow around a set of related activities, clusters of enterprises and industries come together. Tapping these cluster effects can be very effective in accelerating technological competence. Different technologies have different degrees of interaction with outside sources of knowledge (enterprises, consultants, equipment suppliers or technology institutions). These differences in turn lead to different learning costs, risks and duration. A set of policies conducive to the development of one set of capabilities may therefore not be suited to another.

7. Many levels of effort: Capability building involves effort at all levels: procurement, production, process or product engineering, quality management, maintenance, inventory control, outbound logistics, marketing and other outside links. What appear to be routine and easy technical functions, like quality management or

maintenance, can be very difficult to master in a developing country. Most learning in developing countries arises in such mundane technical activities. But formal R&D becomes important in complex technologies, where even efficient absorption requires search and experimentation.

8. Many depths of development: Technological development can take place to different depths. The attainment of a minimum level of operational capability (know-how) is essential to all industrial activity. This may not lead automatically to deeper capabilities, the ability to understand the principles of the technology (know-why). The deeper the levels of technological capabilities, the higher the cost, risk and duration involved. It is possible for an enterprise to use imported technologies without developing the ability to decode the processes to significantly adapt, improve or reproduce them or to create new products or processes. But this is not optimal for long-term capability development. Without technological deepening the enterprise or country remains dependent on external sources for major expansion or improvement to its technologies which is a costly and possibly inefficient outcome. The development of know-why is an important part of overall innovation and learning. It allows a firm to select the new technologies that it needs, lower the costs of buying them, adapt and improve on them more effectively, add more value by using its own knowledge in production and develop autonomous innovative capabilities. The lack of these deeper capabilities may also restrict an enterprise's ability to move up the technology scale even in using higher levels of know-how in its given activity, diversifying into other activities or coping with unexpected demands of technological change. Note that even good follower strategies, in which enterprises efficiently imitate and adapt technologies developed by others (common for efficient enterprises in developing countries), require good know-why capabilities.

9. Foreign plus domestic: Technological interactions occur within and across countries. Imported technology provides the most important initial input into technological innovation and learning in developing countries. Since technologies change constantly, access to foreign sources of innovation remains vital to continuing technological progress. But technology imports do not substitute for the development of indigenous capability. That is the efficacy with which imported technologies are used depends on local efforts. Domestic technological effort and technology imports are largely complementary. But not all modes of importing technology are equally conducive to indigenous learning. Much depends on how the technology is packaged with complementary factors: whether it is available from other sources, how fast it is changing, how developed local capabilities are and the policies adopted to stimulate transfer and deepening. Transfers internal to a firm, as from a trans-national corporation parent to its affiliate, are efficient means of providing the latest know-how, but they tend to be slow in building know-why in the affiliate.

In summation, considerable technological effort is involved in industrial development. This effort can be called technological capability accumulation to the point of innovation, since it differs only in intensity and emphasis from the effort to create new products and processes. Such innovation arises at any point in the value chain—from design and procurement to production, R&D and marketing.

2.7 Imperative of Technological Capability Accumulation in Enterprises

A discussion on the imperative of technological capability accumulation in enterprises is considered to be obvious in this study owing to the fact that technological capability development is the bedrock of industrial development. However the imperative becomes more obvious examining the historical antecedent.

In the early 1960s, developing countries came to terms on the critical need to formulate policies for the advancement of technology. With UNESCO at the forefront, most developing countries proceeded to create institutions whose responsibility was to oversee science and technology (S&T). S&T policy as conceived by UNESCO was delimited to R&D. Thus, the boundary for policy was then primarily concerned with funding R&D and planning the allocation of funds between various R&D agencies. UNESCO's conceptualization of S&T policy at the time was greatly influenced by the 'pipeline model' of innovation (Bell 1985). This model separated technological actors into two components- (i) the technologically active scientists and technologists engaged in R&D in government owned research institutions; and (ii) the enterprises appropriating the results of R&D. The implication of this model and the S&T policies based on it according to Oyeyinka (1997) was that all R&D were practically expected to be funded by government and conducted in government owned institutions. Potential users of the scientific results are expected to perform comparatively little or no research. Unfortunately, the pipeline model and the S&T policy it fostered was not too concerned with how to forge close linkages between the S&T institutions and the users of the R&D outputs.

Following the failure of the pipeline model to advance industrial technology in developing countries, attention then shifted to the firms or enterprises as the main agent in the accumulation of technological capabilities. UNCTAD (1993) conceptualized the firm as a collection of core competences or capabilities. Every firm is a collection of activities performed to design, produce, market, develop, and support its products (Narayanan, 2001) thereby advancing the productivity of nations (Oyeyinka, 1999).

Furthermore, it is imperative for firm to accumulate technological capabilities given the specific, cumulative and partly tacit nature of technology and that most technological learning takes place in firms (Bell and Pavitt, 1993). The very nature of firms' activities and their objectives includes a process of technological learning, to be creative, to be successful, to be relevant and competitive and hence the need to develop technological capability.

2.8 Factors Influencing Firm's Technological Capability Development

From literature, the main influence on firm's technological capability in developing countries can be categorized into two; demand and supply factors. On the demand for efforts to build firm's technological capability, the most important factors are threefold. First there is an inherent need for the development of new skills and information simply to get a new technology into production. This operates regardless of policy regime and provides the elemental drive for firms to invest in capability building; the form that capability building takes depends on the nature of the technology (process or batch, simple or complex, large to small scale). The second is an external factor or the macroeconomic environment which impacts on technology capability investment decision. A stable, high growth environment affects positively the perceived returns to higher investment in firm's technological capability. In addition, competition with international market is probably the most potent inducement to skill and technology upgrading. However, competition is a double-edged sword, and, given the necessary costs of learning, can stifle capability building in newcomers when certain market failures exist. Trade orientation also affects the content and pace of firm's technological capability development. The evidence from a study of technological development in some industries in India and Korea (Amsden, 1989; Kim, 1988; Lall, 1987) suggest that inward-oriented regimes foster learning to "make do" with local materials, "stretch" available equipment for down-scale plants, while export-oriented regimes foster efforts to reduce production costs, raise quality, introduce new products for world markets, and often reduce dependence on (expensive) imported technology.

Third, technological change itself, which proceeds continuously in almost all industries in the developed world, stimulates developing country firms to try to keep up. Exposure to competition mediates this incentive, and highly protected firms can delay their upgrading for long periods. Nevertheless, the existence and potential availability of more efficient technologies can create their own incentives for firms to invest in technological capability.

On the supply factor, the ability of firms to produce new capabilities depends on: the size of firm; access to skills from the market; organizational and managerial skills in the firm and its ability to change structures to absorb new methods and technologies (Katz, 1987; Hoffman, 1989) access to external technical information and support (from foreign technology sources, local firms and consultants, and the technology infrastructure of laboratories, testing facilities, standards institutions, and so on); and access to appropriate "embodied" technology, in the form of capital goods, from the best available sources, domestic or foreign.

In summary, firm technological capability development is the outcome of investments undertaken by the firm in response to external and internal stimuli and in interaction with other economic agents, both private and public and local and foreign. Thus, there are factors that are firm-specific (leading to micro-level differences in FTC development and to "idiosyncratic" results) and those that are common to given countries (depending on their policy regimes, skill endowments, and institutional structures). In more general term, technological capabilities of a firm will be influenced by: (i) broad factors, such as government policies toward education, particularly education in science and engineering, which affect the available supply of technical personnel; (ii) efforts inside the firm to promote learning, such as on-the-job training and R&D activity; and (iii) the availability of micro-level learning support mechanisms, external to the firm, which can be drawn on as the firm seeks to build capabilities.

These external support mechanisms can be private, in that learning occurs as a by product of the firm's normal business transactions, or collective, in that the channels for learning are fostered by a collective effort of government, NGO or donor programs to aid firm-level technical efforts.

2.9 Technological capability building and strategies

The general notion is that technological capability building are usually promoted or brought about through investment in training and R&D or if a firm in an industry desires to be a market leader in the midst of competitors. In which case, technology strategies such as value analysis may be employed. Thus, as commonly known, 'necessity' in many cases is the author of invention or in this case 'technological capability accumulation'. The ICT sector in Nigeria is dynamic and peculiar in the sense that many technological capabilities are developed through serendipity. Furthermore, the technological capabilities in the sector are incrementally developed. The road to technological capability building is technological learning. Some of the strategies that can be employed to develop technological capabilities are: (i) Active involvement of the enterprise staff in the process of technical change; (ii) carrying out of R&D, training and education to upgrade skills; (iii) the hiring of foreign experts (technical assistance) or purchasing technical knowledge and assimilating that knowledge and; (iv) carrying out 'searches' for new techniques and by introducing systemized measurement and instrumentation of these production processes. These strategies are what Akinbinu 2001 referred to as learning efforts that can enhance technological capacity of an enterprise.

3.0 Measurement Priorities

Empirical investigations on the issues pertaining to the acquisition of technological capability have been mainly hindered by the lack of proper measurement methodologies and researchers have made attempts in resolving the problem in literature. Most studies in developed and developing economies would employ conventional proxies such as technical manpower available for technical tasks, patents, publications, innovations and R&D expenditure for measuring technological capabilities. These are usually used to determine the relative technological strengths and efforts of firms. However, these metrics are not assessing true technological strength (Acha, 2000). Raghavendra and Subrahmanya, 2006 in their study used a proxy called 'technology level' to measure the technological capability of a foundry firm. This proxy ascribed a rating to the technological expertise of the employees to perform some functions and process in manufacturing. However, most studies in developing country context (Lall, 1992; Biggs, Shah and Srivastava, 1995, and Aires 2005) saw technological capabilities as covering a wide spectrum of technical efforts undertaken by firms and therefore categorize these capabilities into three functional groups: investment capabilities, production capabilities, and learning mechanisms. Aires 2005 further divided learning mechanisms into adaptive innovation capability and networking capability. The first set of capabilities refers to the skills and information needed to identify feasible projects, locate and purchase suitable technologies, design and engineer the plant, and manage the construction, commission and start-up. The skills and knowledge needed for the subsequent operation and improvement of the plant are defined as production capabilities. Lastly, the learning mechanisms available to firms determine the extent to which they can augment their endowments of production and investment capabilities over time. Together, the three types of capabilities determine how efficiently firms organize and manage their activities, which are regarded as their total factor productivity. Some authors (Lall, S., G.B. Navareti, S. Teitel and G. Wignaraja, 1994) view technological capabilities in terms of investment and production capabilities.

Investment capabilities are the skills and information needed to identify feasible investment projects, locate and purchase suitable (embodied and disembodied) technologies, design and engineer the plant, and manage the construction, commissioning and start-up. It is believed from the experience of Japan and the Asian Newly-Industrialized Countries that growth in the domestic ability to select technologies, negotiate favourable terms for its transfer and participate in the design and setting up of the plant can greatly reduce project costs and increase the subsequent capabilities for technology adaptation and improvement.

Production capabilities are the skills and knowledge needed for the operation and improvement of a plant. As the table shows, these capabilities range from routine functions to intensive and innovative efforts; adaptation and improvement in technology. Production capabilities include both process technological capabilities as well as product capabilities, such as product redesign, product quality improvement and introduction of new products. In addition, production capabilities also cover monitoring and control functions included under industrial engineering. Industrial engineering skills are required to improve productivity by changing the time and spatial sequencing of manufacturing and auxiliary operations.

4.0 Roles of Government in Technological Capability Building

There has been increasing interest in the role of government in technology capability development and also in R&D. This is because for most nations that can be termed ‘developed’ today, government had played a pivotal role in setting priorities and devoting resources to bring about sustainable development. Here, though the interest lies in technology capability building, we include R&D because expenditures on R&D are considered as a key determinant for the acquisition and accumulation of technological capabilities. For instance in Finland, Europe, government R&D funding on Science and Technology (S&T) alone is 1798 million euro in 2007. This amount was tapped by both public and private S&T based organizations and firms. Moreover, their Science and Technology Policy Council has key government officials such as the prime minister; minister of education and science; minister of economic affairs; minister of finance; four other ministers aside other key stakeholders as members. Thus, government has the roles of setting priorities, participating and funding research and development activities that could enhance technological capability development and accumulation. Furthermore, productive, technological, organization and institutional changes are important outcomes of the process and accumulation of technological capabilities which in turn serve as instrument for long-term development. Government has the principal role to drive these kinds of changes by virtue of their legislative functions.

5.0 The ICT Industry in Nigeria

The ICT industry in Nigeria consists of players involved in hardware and peripheral assembly and manufacturing; sales and services of hardware, peripherals and consumables; information technology consultancy and solutions providers; printers and photocopiers re-manufacturers and recyclers ; educational and training services; software development and marketing; system engineering and systems support services; network service providers among others. From the Goldstar Directories of the major 5,000 companies in Nigeria (2007/08) the categories shown in Table 7 were made.

Thus, about 21% of the top 5000 companies in Nigeria are ICT firms. The number of employees of individual firm within a group range between 10 and 300. Some of these companies are situated in the popular Otigba cluster described by Oyeyinka *et al*. (2007) which consist of highly skilled entrepreneurs basically involved in computer hardware assembly technology, sales and services. The cluster had boosted the growth of the industry and the duplication of such clusters is recommended in other states of the country and even in other industry because it enhances technology-learning process and industrial growth.

5.1 Innovation and the ICT Industry

The highly innovative ICT sector invests heavily in R&D. In 2004, ICT manufacturing industries accounted for more than a quarter of total manufacturing business R&D expenditure in most OECD countries. They accounted for more than half in Finland and Korea (63 and 57%, respectively), and more than 30% in the United States (39%), Canada (38%) and Ireland (34%).

In countries with data for both manufacturing and services industries, expenditure on R&D generally expanded in ICT-related service industries but contracted in ICT-related manufacturing industries. However, investment in R&D still accounted for a small share of GDP in both sectors (less than 1.3% in the former and less than 0.2% in the latter). Only Norway and Sweden reported a decrease in R&D investment as a share of GDP in ICT-related service industries in 2004.

The ratio of R&D expenditure to GDP or to total business enterprise R&D can be a sign of R&D specialisation. Finland is clearly more specialised than large countries in both ICT manufacturing and services. In 2004, it allocated 1.3% of GDP to ICT-related manufacturing R&D, compared to 0.79% in 1997.

Table 7: Categories of ICT companies among the major 5,000 in Nigeria.

S/No	ICT Firm's Nature of Activity	No in Group	Employees
1.	Hardware and peripheral assembly and manufacturing	2	252
2.	Sales & services of hardware, peripherals and consumables	289	5732
3.	Information technology consultancy & solutions providers	87	3108
4.	Printers toners & photocopiers re-manufacturers and recyclers	2	61
5.	Educational and training services	63	1961
6.	Software development and marketing	75	3368
7.	System engineering and systems support services	109	4349
8	Internet service providers	51	2038
9.	Internet Designers and Engineering Services	32	800
10	Telecommunication Engineers and Consultants	43	1300
11	Telecommunications Equipment & Systems sales & services	80	2800
12	Telephone (fixed wireless/mobile) service providers	14	560
13	Telephone (GSM) and accessories sales and repairs	42	1890
14	Telephone (pre-paid cards) operators	18	630
15	Telephone (wired/fibre-optic) service providers	2	129
16	Telephone (cable) re-broadcasting services	3	53
17	Office automation, business machine & equipment sales & services	72	2872
18	Satellite (VSAT) Communication engineering services	44	1760
19	Satellite (VSAT) Communication Equipment	30	1200
20	Telecommunication (non-telephony) service providers	5	192
21	Telecommunication consultancy services	3	40
	Total	1066	35095

6.0 Technological Capabilities, Innovation and the Challenge of Policy

Technological capabilities are key assets that enable a country and its enterprises to compete internationally and attain reasonable level of economic progress. Meanwhile, continuous innovation is one of the drivers of international competitiveness and economic progress. Thus, Olamade 2002 described technological capabilities as the resources that are organised to generate innovations, which may be incremental, radical, adaptive or modified. In recognition of the relationship between technological capabilities and innovation therefore, Science and Technology (S&T) policies are no longer sufficient to address issues of technological development but a more robust agenda of innovation policy is needed to support existing S&T policy. S&T policy consists of principles and methods, together with the legislative and executive provisions required to stimulate, mobilise and organise a country's scientific and technological potential for the implementation of the national development plan (UNESCO cited in Olamade 2002). An innovation policy, on the other hand, goes further to integrate S&T policy with conventional industrial policy.

As early as in the 1980s, OECD countries were making efforts to harmonise their economic, technological and social policies to optimize the contributions of technological development to economic and social development (OECD 1980 cited in IDRC 1999). In this regard, important efforts that sought to delineate the policy significance of the concept of National System of Innovation (NIS) were held in high consideration. Probably the most influential early publication on the subject was that edited by the Danish scholar, Lundvall 1992. Today, the industrialized countries have reached the conclusion that technical change is the principal driving force behind economic growth within their economies. Further, it is also understood that technical change has two primary sources - technological innovation and technology diffusion. This latter concept - technology diffusion - is crucially important and has embedded within it the need for technology recipients to participate in a continuing process of incremental innovation to adjust the acquired technology to the needs of the markets and supply systems of the technology user. In simplicity, the 1960s and early 1970s are considered as the era of science policy, the late 1970s and 1980s as the era of S&T policies; and the 1990s as the era of science, technology and innovation policies (IDRC, 1999). During these years there has been a global process of cumulative learning about the range of issues that need to be encompassed in the attempt to harness the forces of technological change to national economic and social development.

Rothwell (1984) drawing from the experiences of industrialized countries identified the following as problems associated with innovation policy:

- Too easily obtainable government funds devoted to projects of high technical sophistication but low market potential and profitability and projects involving higher technical and financial risk than those funded wholly by private companies;
- Lack of capacity on the part of public policy-makers to identify high technical risk projects that also have high market potential;
- Concentration of government fund in assisting large firms that might be expected to be able to support major projects to the neglect of small firms. Whereas convincing evidence supports that in many sectors, small firms can make significant contributions to national rates of innovation (Rothwell and Zegveld 1982 cited in Olamade 2002).
- Passive stance towards information dissemination so that small firms are largely unaware of many governmental measures that are available to assist them. In some cases where small firms are well informed, many of them do not possess the technical expertise to enable them exploit the available measures;

- Lack of practical knowledge of or imaginative conceptualization of the process of industrial innovation by policymakers, resulting in them adopting a narrow heavily R&D oriented view of innovation to the detriment of other important aspects such as innovation-oriented public purchasing;
- Lack of inter-departmental co-ordination in the formulation and implementation of a coherent innovation policy resulting in contradictions in policies
- Policies are often subject to major changes in accordance with political situation rather than with changing industrial or economic needs or conditions;
- Most policies fail to make explicit distinction between existing small firms in the traditional areas of industry and new technology-based small firms with a view to harnessing the latter's potential for both innovation and employment generation.

However, more specifically, most developing countries undertake industrialization without an explicit S&T policy. In this respect, developing countries assume that substituting imports with direct foreign investment was an appropriate industrialization policy that would eventually lead to an automatic transfer of capital, management skills, and technical knowledge. Such transfers eventually never take place. It is now widely accepted that effective transfer of technology requires a deliberate S&T policy in the recipient country to ensure that various technologies are compared; the appropriate one is selected for transfer; and the effectiveness of the transfer, assimilation, and adaptation of the selected technology is monitored (Smith, 2005). The major gap in S&T policies in developing countries is the lack of coordination of S&T institutions and activities which result in lack of synergetic efforts that could bring about industrial development. At present, in most of these countries including Nigeria, various ministers regulate different aspects of industry, which is inefficient because there is little consultation among them. The need for African economies to undergo deep technological revolutions that would bring about rapid structural shifts to deepen their industry, and build up their endogenous technological capability have been emphasised in the literature (IDRC, 1995), Furthermore, there is a general problem of non conducive enabling macroeconomic environment and the ways that environment interacts with an effective technology policy. Science, Technology and Innovation policy in developing economies are yet to be fully integrated with the environment to bring about technological learning, the right technical choices, the setting up of appropriate institutions, and effective technological management for both the industrial and agricultural sectors, including those small and medium-sized enterprises that are now so vital for income and employment.

The Nigerian National Policy on Science and Technology was first published in 1986 and revised in 1999 for a 25-year time frame with a provision for revision at 5-year intervals and current revision (2003). Its basic philosophy emphasizes Nigeria's commitment to the creation of an independent, integrated and self-sustaining economy, with the National Policy itself being the framework for effort towards the fulfilment of the commitment. However, the problem with the policy document has always been that of implementation. A study by Abdullahi (2004) confirmed the fact that S&T policy has not played a critical role in national development and that Nigerian society is not aware of and hardly contribute to formulation of S&T policy. Furthermore, the study revealed that development process in Nigeria failed to recognize the critical role of scientific and technological activities. The country lacked science culture and the existing institutional capacity for S&T development is very weak in terms of requisite personnel and facilities. The study concluded that a new policy shift is desirable which emphasizes the promotion of S&T culture, its integration into the production system and the strengthening of institutional framework for policy formulation, implementation, monitoring and evaluation in addition to promotion of S&T literacy. Thus, myriad of inadequacies exist in the S&T system in Nigeria which is also common in most developing countries. Others are:

- Due to inability to tract the direct relationship between benefits, and expenditure and the time- lag involved on Research and Development, it is often not easy to convince the government to invest on Science and Technology.
- Science, Technology and Innovation concepts are not well understood by the society and thus the implementation of its policy guidance has not been able to produce any noticeable results.
- The management of science and technology system is not well developed yet. This often leads to duplication of efforts by the stakeholders.
- The interest in "indigenous technologies and knowledge," is hampered by, deeper interest for foreign goods, western science culture and systems and counter policies promoting the importation of such. This weakens and kills existing small enterprises venturing on indigenous technologies and knowledge. It also discourages the emergence of science-based industries arising from domestic-scientific efforts. Many are ignorant of Intellectual Property Rights Systems and the bibliometrics used as one method of measuring R & D output is foreign.
- Poor facilities and strategies to undertake R & D, auditing and technological assessment at national level.

- Inadequate human resource base and lack of capacity to implement and facilitate the smooth running of the system.

7.0 Development of the Conceptual Framework

In order to derive the basis for which information can be collected for the study of technological capability building, concepts and activities that constitute technological capability development in product and process technology were considered. Various theoretical perspectives were drawn on in literature and this study propose a direct relationship between technological capability and performance (including adaptive and incremental product development and annual turnover), the mediating role of customer value, the possible moderating effects of business environment and other important contingent factors such as learning orientation. A conceptual framework that examines these relationships in general and in various contexts, which is believed more important and useful for firms to manage their technological capability more effectively, is devised.

Scholars of technological capabilities development have made efforts to explain the dynamic nature of the process of technological capability building as having diversified activity with many interacting components. Thus, this study concentrates on the process of technological capability building and accumulation at the level of the firm. Figure 4 shows the schematic of the conceptual framework for the study.

From Figure 4, either external or internal factors to the firms determine and influence the technological capabilities available in firms. The external factors include competition, technological change, skills from the labour market, technical information/support, government policy and licensing. The internal factors include on-the-job training, R&D, ownership structure, funds, working experience and linkages. These factors interact to determine the functional capabilities available in firms such as investment, production and networking capabilities. The performance and mastery of these functions generate technological innovations in terms of adaptive and improved product and process that can be found in the industry and invariably determines the performance of the firms. The performance here referred to is the annual turnover as well as the number of technological innovations, patents and license acquired by the firms for the period under consideration. The framework suggests a process whereby the performance of the industry is evaluated and reviewed, and this forms the basis on which appropriate interventions are proposed. Such interventions would either emanate from the firm or external environment (for instance government policies) and will serve as input to the system to bring about the desired technological capability, technological innovations and improved overall performance.

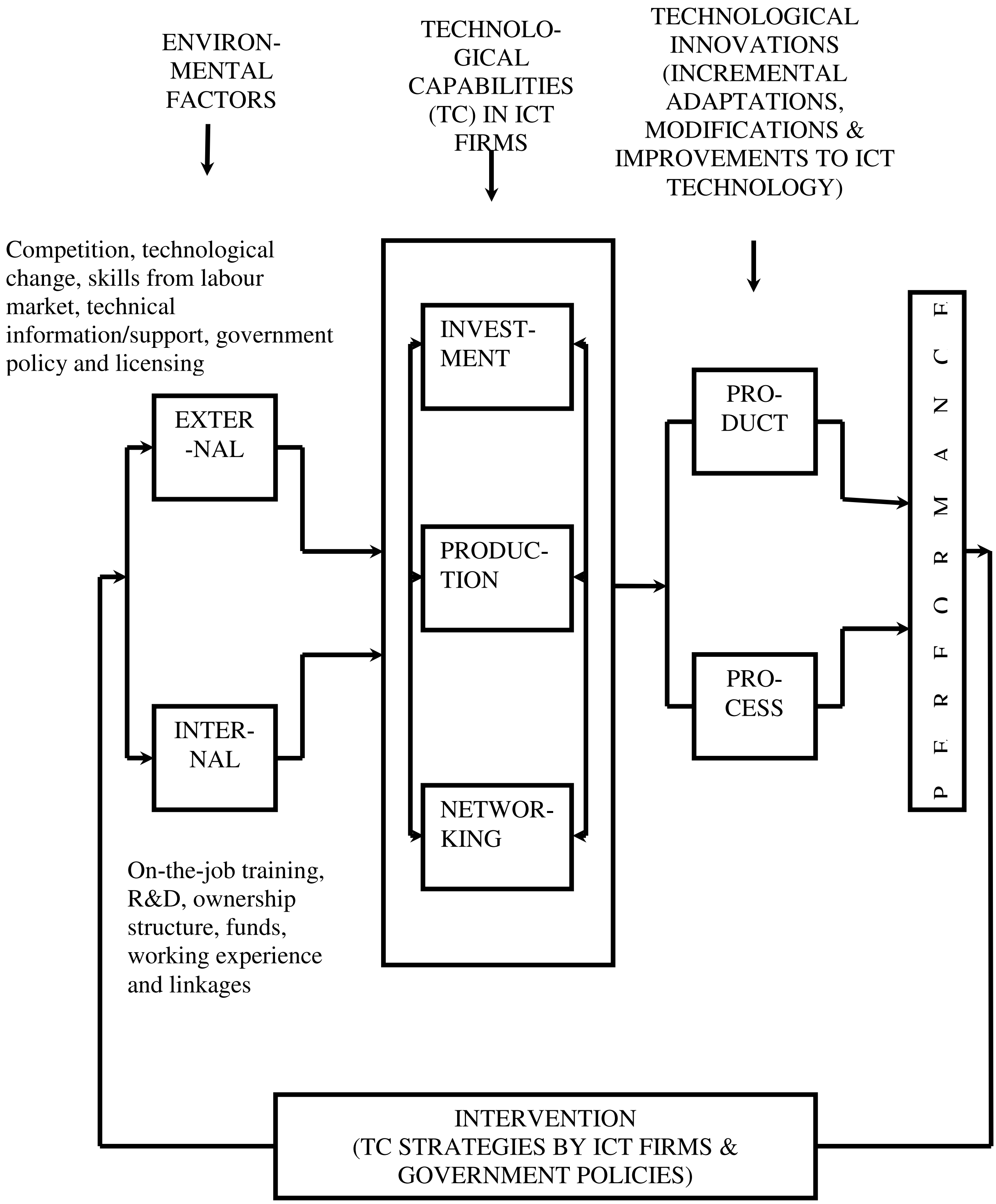

Figure 4: Conceptual Framework for the Study of Technological Capability in ICT Industry

7.1 Link between the theoretical underpinnings for the study and the conceptual framework

In this work, the Jacobs et al (1999) theory describing development as a function of society's capacity to organize human energies and productive resources to respond to opportunities and challenges is visited. Jacobs et al theory identifies the human resource as the driving force and primary determinant of development; other resource- money, materials, and mansion though important, are secondary. This study expanded upon this theory with explicit reference to intra-firm technological learning processes (Kim, 1997; Oyeyinka, 1997; Biggs et al, 1995; Akerele, 2003; Bell and Pavitt, 1993, Lall, 1987; Akinbinu, 2001) and interacting environmental factors which broadly speaking include policy, market and institutional frameworks as theorized by Ergas, 1984,1986; Fagerberg, 1987; Dosi et al, 1988; and OECD, 1987. All of these culminate to technological capability development in firms as well established in development studies literature (Bell and Pavitt 1993; Dutrenit 2000; Ernst et al. 1998a; Figueiredo 2001; Hobday 1995c; Kim 1997b; Kim and Nelson 2000; Lall 1992; Marcelle 2004). This work goes further to link the generation of technological innovations, profit and growth as resulting from the accumulation of technological capability. This position is theorised and summarised somewhat as the evolutionary or institutional model of the firm which in modern economic theory is a shift from the neoclassical to the evolutionary economic approaches.

In summary, modern, evolutionary economics sees the firm as a searching, learning mechanism. It survives and improves by continually reinventing itself. The firm consists of two elements (Arnold, E. and Thuriaux, B. (1997): i) A pool of assets, including both physical assets and intangible ones such as capabilities; 2) Intelligence, which learns from the environment and modifies the resources. Each of these elements can be broken down much further. An important attribute of the firm's 'memory' is that it comprises a mixture of knowledge (tacit as well as codified) and of the configuration of assets: namely, organisation, characteristics of the capital stock, relationships, and so on. One of the primary concerns in this work is to identify the essential technological capabilities needed for technological innovation.

7.2 Area of Study

The study areas include Lagos, the Federal Capital Territory – Abuja, Portharcourt and Kaduna. These cities were selected based on their predominant commercial activities, their age-long existence and the presence of most ICT firms. Furthermore, the popular Otigba cluster which is believed to be representative of ICT developments rapidly taking place in other cities of Nigeria and even in Africa is situated in Lagos.

In addition, ICT firms involved in development/manufacturing, assemblage, repairs and maintenance of ICT hardware and software were examined in the study. This is because these firms have interrelated developmental activities which provide details on the nature of technological effort undertaken in the industry.

7.3 Research Instruments

The study employed the use of structured questionnaires and personal interviews to obtain primary data from mainly ICT firms involved in production, engineering, maintenance of ICT hardware and software. Secondary data from reports, journals, internet, government publications and newspapers were also used.

7.4 Sample Population and Sampling Technique

Primary data on existing technological capabilities, types and degree of novelty of technological innovations, factors influencing technological capability were obtained through questionnaire administration from all the 185 small and medium ICT firms (Lagos 140; Abuja 30; Port Harcourt 13; and Kaduna 2) involved in assemblage and manufacturing of computer hardware, software development, toner and other peripherals remanufacturing as published in the Goldstar directories of 2007/2008.

8.0 Technological Capabilities in ICT Firms and Measurement

Functional technological capabilities are divided into three major categories: investment capability; production capability; networking and linkage capability The variables to be considered under the three categories and the method of measurement are as follows:

A. Investment capability

This is the ability and skill needed before a new facility is commissioned or existing plant is expanded. The tasks involved include identifying needs, preparing and obtaining the necessary technology. This is followed by design, construction, equipping, and staffing the facility. They determine the capital costs of the project, the appropriateness of the scale, product mix, technology, and equipment selected. The performance of this function brings about an understanding of the basic technologies involved and in turn, affects the efficiency with which the firm later operates the facility.

Parameters for determining investment capability function include:

i. Feasibility studies (IC_1)

This is an important aid in project formulation and implementation. It is usually prepared for new or existing businesses to help generate, crystallise and focus ideas, to set objectives and monitor performance. Usually, feasibility studies are a pre-requisite for any successful venture/project because of its detailed, functional and technical nature. In the process of engaging in feasibility studies, firms develop in-depth knowledge of their product and the learning process is enhanced.

It is one of the functional technological capabilities to be investigated in the ICT firms. The firms would be asked to indicate the number of successful feasibility studies they have engaged in since inception as well as the amount spent. Furthermore, they were asked to rate the ability and skill of their firm to perform the capability function in-house under a rating of 5 – Excellent; 4 – Very good; 3 – Good; 2 – Fair; 1 – No skill between 2003 – 2007.

ii. Search for technology source (IC_2)

This refers to the skill and information needed to search for, identify and locate sources of technologies. In the case of ICTs source in Nigeria, most of the firms rely on importation of components, small parts and heavy machineries. In the process of performing such function, the firms develop technological capability in knowing different sources of their product and the different peculiar environment and circumstances that actualize the production of such technologies from the country of importation. The function was measured under a five scale rating of the ability and skill of the firm to perform the capability function in-house under a rating of 5 – Excellent; 4 – Very good; 3 – Good; 2 – Fair; 1 – No skill between 2003 – 2007.

iii. Assessment of technologies (IC_3)

Plant and machinery constitute more than 60% of total capital outlay of an industrial outlay. Thus firms should carefully consider selection process, production factors and appropriateness of technology selected based on environmental, political and technical factors. Thus the ability to assess the ICTs as being capable of performing the required functions is entailed in assessment of technology. The function was measured under a five scale rating of the ability and skill of the firm to perform the capability function in-house under a rating of 5 – Excellent; 4 – Very good; 3 – Good; 2 – Fair; 1 – No skill between 2003 – 2007.

iv. Equipment procurement (IC_4)

The act of procurement requires some level of knowledge about the item to be procured. Performance of this function develops the skill of the entrepreneur to be able to identify and differentiate between various technologies, machineries and facilities. The function was measured under a five scale rating of the ability and skill of the firm to perform the capability function in-house under a rating of 5 – Excellent; 4 – Very good; 3 – Good; 2 – Fair; 1 – No skill between 2003 – 2007.

v. Recruitment of skilled personnel (IC_5)

Recruitment of skilled personnel is a key function in fostering the dissemination of technological knowledge. While some countries have relied extensively on Multinationals Corporation as far as recruitment of skilled personnel is concerned, others have relied on protecting domestic infant industries though securing access to technology through licensing. However, there are imbalances in the national supply and demand of skilled personnel in the economy. The prevailing situation is that the industry is finding graduates unemployable. Thus recruited personnel are groomed through in-house training to meet the need in industry. The firms were asked to state the number of skilled personnel recruited between 2003 and 2007. The function was also measured under a five scale rating of the ability and skill of the firm to perform the capability function in-house under a rating of 5 – Excellent; 4 – Very good; 3 – Good; 2 – Fair; 1 – No skill between 2003 – 2007.

vi. Involvement of the firm in detailed engineering (IC_6)

New and imported technologies such as ICTs have large tacit element that has to do with embodied information that is difficult to articulate and can only be acquired through training, information search, experience and deliberate involvement in engineering activities or technology unpackaging. Involvement in detailed engineering would enable the firm to comprehend the components that makes up the ICT and how it operates. They would also be able to carry out repairs, replacement and maintenance functions on the ICTs. The function was measured under a five scale rating of the ability and skill of the firm to perform the capability function in-house under a rating of 5 – Excellent; 4 – Very good; 3 – Good; 2 – Fair; 1 – No skill between 2003 – 2007.

B. Production capability

Production capability includes process and product engineering and involves the following functions:

i. Quality management (TC_1)

Quality control function is a means of reinforcing technological capabilities of domestic knowledge system. Particularly, for ICT industry there should be constant upgrade of testing and measurement strategies to ensure quality control. Firms are to frequently ensure that imported and improved processes and products are being tested to comply with established standards such as ISO 9000. Firms were asked to indicate the actual number of skilled personnel in their firm that can carry out the production function between 2003 and 2007. The function was also measured using a rating of: 5 – Excellent; 4 – Very good; 3 – Good; 2 – Fair; 1 – No skill; for the ability or skill of the firm to carry out the production function in-house between 2003 and 2007.

ii. Debugging (TC_2)

Debugging is a term commonly used in software development. It means the 'perfection' of a software program by tracing and correcting error messages. Debugging can apply to both software and hardware product or process development function. In the process of debugging, firms develop their technological capability as they gain mastery of the process or product under development. Firms were asked to indicate the actual number of skilled personnel in their firm that can carry out the production function between 2003 and 2007. The function was also measured using a rating of: 5 – Excellent; 4 – Very good; 3 – Good; 2 – Fair; 1 – No skill; for the ability or skill of the firm to carry out the production function in-house between 2003 and 2007.

iii. Maintenance management (TC_3)

Capability building involves effort at all levels including routine and preventive maintenance. What appears to be routine and easy technical functions, like quality management or maintenance, can be very difficult to master in a developing country. Most learning in developing countries arises in such mundane technical activities. It would be desirable to know how often ICT firms practise routine and preventive maintenance. Thus firms were asked to indicate the actual number of skilled personnel in their firm that can carry out the production function between 2003 and 2007. The function was also measured using a rating of: 5 – Excellent; 4 – Very good; 3 – Good; 2 – Fair; 1 – No skill; for the ability or skill of the firm to carry out the production function in-house between 2003 and 2007.

iv. Plant layout for cost saving (TC_4)

This is the arrangement of plant and machineries, facilities and other services in the factory or business premises for easy access and efficiency of operation. Bad layout could result in congestion of materials, components and assemblies, excessive amount of work-in process, poor utilization of space, production bottlenecks at certain machines while some facilities or machine are lying idle, delay in delivery, mental or physical strain on operators or workers and difficulty in maintaining effective supervision and control. Plant layout constitutes a very important technological effort that could save huge sum of production cost. A good plant layout capability with emphasis on quality control, routine maintenance with negligible breakdown rates and frequent changes in plant layout constitute one of the best production capabilities. The study verified the actual number of skilled personnel in the firms that can carry out the production function between 2003 and 2007. The function was also measured using a rating of: 5 – Excellent; 4 – Very good; 3 – Good; 2 – Fair; 1 – No skill; for the ability or skill of the firm to carry out the production function in-house between 2003 and 2007.

v. Inventory control (TC_5)

Continuous and systematic productivity analysis and benchmarking as well as supply chain and logistics require technological effort in inventory control. Firms are expected to use and apply new techniques such as Just-In-Time (JIT) and Total Quality Management (TQM) in procurement and inventory control just like the Japanese did to gain industrial revolution. Firms were asked to indicate the actual number of skilled personnel in their firm that can carry out the production function between 2003 and 2007. The function was also measured using a rating of: 5 – Excellent; 4 – Very good; 3 – Good; 2 – Fair; 1 – No skill; for the ability or skill of the firm to carry out the production function in-house between 2003 and 2007.

vi. Improvements in processes (TC_6)

One of the manifestations of innovation and learning are improvements and adaptations to processes, drawing on in-house technical efforts, outside sources of knowledge and interaction with leading international enterprises. Minor improvements and adaptations are part of gaining capabilities in efficient production processes. But major improvements and adaptations require higher levels of enterprise skill and competence—and generally a more advanced industrial system and infrastructure. Improvements in processes include assimilation of process technology to process adaptation and cost saving. It also involves monitoring productivity processes and improving coordination. The firms were asked to mention the name of such improvements they have undertaken. They were asked to rate the success/functionality of the process they have improved using a rating of: 5 – Excellent; 4 – Very good; 3 – Good; 2 – Fair; 1 – Not successful/functional. They were also asked to indicate the actual number of skilled personnel in their firm that can carry out the production function between 2003 and 2007. In addition, the function was measured using a rating of: 5 – Excellent; 4 – Very good; 3 – Good; 2 – Fair; 1 – No skill; for the ability or skill of the firm to carry out the production function in-house between 2003 and 2007.

vii. Copying imports (TC_7)

This includes activities such as assemblage and adaptive innovation capability. The firms would be asked to state the number and name of such improvements they have undertaken. The firms were asked to mention the name of such imports they have copied. They were asked to rate the success/functionality of the product/device using a rating of: 5 – Excellent; 4 – Very good; 3 – Good; 2 – Fair; 1 – Not successful/functional. They were also asked to indicate the actual number of skilled personnel in their firm that can carry out the production function between 2003 and 2007. In addition, the function was measured using a rating of: 5 – Excellent; 4 – Very good; 3 – Good; 2 – Fair; 1 – No skill; for the ability or skill of the firm to carry out the production function in-house between 2003 and 2007

viii. Improving existing products (TC_8)

Improving existing products include activities such as modifying products to suit local environment. This involves assimilation of new imported product technology and product design to minor adaptation to suit markets needs; product quality improvements. The firms were asked to state the name of such improvements they have undertaken. They were asked to rate the success/functionality of the product/device they have improved using a rating of: 5 – Excellent; 4 – Very good; 3 – Good; 2 – Fair; 1 – Not successful/functional. They were also asked to indicate the actual number of skilled personnel in their firm that can carry out the production function between 2003 and 2007. In addition, the function was measured using a rating of: 5 – Excellent; 4 – Very good; 3 – Good; 2 – Fair; 1 – No skill; for the ability or skill of the firm to carry out the production function in-house between 2003 and 2007

ix. Introducing new products (TC_9)

This involves in-house product innovation and even basic research to industrial engineering work flow, scheduling, time-motion studies. The firms were asked to state name of such products they have introduced/developed. They were asked to rate the success/functionality of the product/device using a rating of: 5 – Excellent; 4 – Very good; 3 – Good; 2 – Fair; 1 – Not successful/functional. They were also asked to indicate the actual number of skilled personnel in their firm that can carry out the production function between 2003 and 2007. In addition, the function was measured using a rating of: 5 – Excellent; 4 – Very good; 3 – Good; 2 – Fair; 1 – No skill; for the ability or skill of the firm to carry out the production function in-house between 2003 and 2007

x. Licensing new product technology (TC_{10})

This has to do with entering into an agreement with another firm to use or manufacture their product which usually is protected by intellectual property rights (IPR). Licensing promotes technology transfer and technological capability development. The firms were asked to state the name of such licensing agreement they have undertaken. Firms were asked to indicate the actual number of skilled personnel in their firm that can carry out the production function between 2003 and 2007. The parameter was also measured using a rating of: 5 – Excellent; 4 – Very good; 3 – Good; 2 – Fair; 1 – No skill; for the ability or skill of the firm to carry out the production function in-house between 2003 and 2007.

xi. Experimental Development (R&D) (TC_{11})

Experimental Development is a kind of research and development (R&D). While R&D is creative work that is undertaken on a systematic basis, in order to increase the stock of knowledge, and to use the stock of knowledge to devise new applications; Experimental development is defined as systematic work that draws on existing knowledge gained from research and practical experience in order to produce new materials, products and devices, to install new processes, systems and services, or to improve substantially those already produced or installed. The Frascati manual define the scope of experimental development as involving an apparently extensive range of activities. Such activities include calculations, designs, working drawings and operating instructions made for the setting up of pilot plants and prototypes. The respondents were asked to state the amount spent on R&D between 2003 and 2007. They were further asked to indicate the actual number of skilled personnel in their firm that can carry out the production function between 2003 and 2007. The function was also measured using a rating of: 5 – Excellent; 4 – Very good; 3 – Good; 2 – Fair; 1 – No skill; for the ability or skill of the firm to carry out the production function in-house between 2003 and 2007.

xii. Patent (TC_{12})

Patents are usually considered as a measure of technological efforts. It is used here in this study as a production capability indicating the ability of the firms to engage in meaningful productions and have copyrights to his credit. The respondents were asked to state the number of patents they have been granted between 2003 and 2007.

C. Networking and linkage capability

Linkages in this study include supplier firm linkages, subcontracting linkages and linkages with institutions that provide trouble-shooting, testing, training and product design assistance. It also includes external linkage with openly available information sources that does not require purchase of technology or intellectual property or interaction with the source. The firms were asked to indicate the number of existing linkage/networking they have in the years 2003 to 2007 with government laboratories (NLC_1), universities or polytechnics (NLC_2), ICT regulatory body (NLC_3), competitors (NLC_4), suppliers (NLC_5), and financial resources (NLC_6). The parameter was also measured using the intensity of firms' collaborative efforts with sources of Information and Knowledge, Sources of Technology/Process, Human Resources, Financial Resources, Government laboratories, Universities or polytechnics, Competitors, Suppliers and Policy institutions/Regulators on a five-scale rating of 5-Excellent, 4-Very Good, 3-Good, 2-Moderate, and 1-Poor. The firms were asked to indicate whether they are involved in outsourcing or subcontracting. Finally, the parameter was measured on a 3-item scale of the best description of firms' linkage and networking activities in the categories: (a) External linkage with openly available information sources that does not require purchase of technology or intellectual property or interaction with the source ; (b) Acquisition of rights to use patents and non-patented inventions, trademark and knowledge from local/foreign firms, competitors, universities and government research institutes that do not involve interaction with the source; and (c) Active innovation co-operation with other local/foreign firms and public research institutions, subcontracting and outsourcing of product, components, machinery, software (which may include purchase of knowledge and technology)

9.0 Factors Influencing Technological Capability Development and Measurement

The factors to be measured as influencing the firm's technological capability are categorized into two; Internal and external. Mathematically, technological capability (TC) in ICT industry is considered as an objective function with various independent variables and is given by:

$$IC = f(x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8, x_9, x_{10}, x_{11}) + f(y_1, y_2, y_3, y_4, y_5, y_6, y_7) + S_1, \ldots \text{(1a)}$$

$$PC = f(x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8, x_9, x_{10}, x_{11}) + f(y_1, y_2, y_3, y_4, y_5, y_6, y_7) + S_2, \ldots \text{(1b)}$$

$$NC = f(x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8, x_9, x_{10}, x_{11}) + f(y_1, y_2, y_3, y_4, y_5, y_6, y_7) + S_3, \ldots \text{(1c)}$$

Where IC = Investment Capability; PC = Production Capability; NLC = Networking and Linkage Capability; and $f(x_1 \ldots x_{11})$ are the Internal factors and $f(y_1 \ldots y_7)$ are the external factors impacting on TC in firms and $S_1 \ldots S_3$ =Residual factors or slack variables.

The relationship (equation 1a – 1c) was established using cross tabulation, chi-square and multiple regression analysis. The independents variables are described below.

A. Internal factors

i. Inherent need for the development of new skills and information (x_1)

The firm may develop a fundamental need to acquire information and develop new skill to enable them meet the demand in the market. This kind of natural or intrinsic desire often leads to technological capability in the area of skill acquired. The factor was measured on a four scale rating of extent to which it impacts on the development of TC in firms thus; 4-Highly, 3-Moderately, 2-Slightly, and 1-not at all.

ii. On-the-job training (x_2)

On-the-job training (OJT) is one of the best training methods because it is planned, organized, and conducted at the employee's worksite. OJT is generally the primary method used for broadening employee skills and increasing productivity (US Department of the Interior, (1998). It is particularly appropriate for developing proficiency skills unique to an employee's job - especially jobs that technological in nature and requires either imported or locally-owned equipment or facilities.

Morale, productivity, and professionalism will normally be high in those organizations that employ a sound OJT program. An analysis of the major job requirements and related knowledge, skills, and abilities form the basis for setting up an OJT plan. To be most effective, an OJT plan should include: The subject to be covered; Number of hours; estimated completion date; and method by which the training will be evaluated. To have a successful OJT program, supervisors need to assign a coach to each employee involved in OJT. It is the responsibility of the coach to plan training carefully and conduct it effectively. The parameter was measured on a four scale rating of extent to which it impacts on the development of TC in firms thus; 4-Highly, 3-Moderately, 2-Slightly, and 1-not at all.

iii. Research and Development (R&D) (x_3)

R&D according to the Organization for Economic Co-operation and Development refers to "creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of human, culture and society, and the use of this stock of knowledge to devise new applications". New product design and development is more than often a crucial factor in the survival of a company. In a dynamic industry like ICT, firms must continually revise their design and range of products. This is necessary due to continuous technology change and development as well as other competitors and the changing preference of customers. Nigerian ICT fims must research making adaptive and modified products to suit the local environment since ICT is a foreign technology to the country. The factor was measured on a four scale rating of extent to which it impacts on the development of TC in firms thus; 4-Highly, 3-Moderately, 2-Slightly, and 1-not at all.

iv. Ownership structure (x_4)

This has to do with the way in which the business is organized. The form of a business determines how many owners it has and its financial situation especially in the aspect of the potential risks and liabilities of the business; the formalities and expenses involved in establishing and maintaining the various business structures, the income tax situation, and the investment needs. In particular, investment, productions and linkages decisions would depend on the firm ownership structure. The study did not use the conventional seven item scale (sole proprietorship, partnership, limited partnership, limited liability company (LLC), corporation (for-profit), non profit corporation (not-for-profit), and cooperative) but used a three item scale of 'fully owned by Nigerian individual (s)'; 'joint venture between Nigerian and foreign individual (s)'; 'fully owned by foreign individual (s)'. This is because the study is interested in capturing the share of the sampled firms owned by multinationals. The parameter was measured as a factor influencing TC using a four scale rating of extent to which it impacts on the development of TC in firms thus; 4-Highly, 3-Moderately, 2-Slightly, and 1-not at all.

v. Funds for Training (x_5)

For technological capability development, the need to set aside funds for manpower development and learning cannot be overemphasized. The respondents would be asked to state the amount spent on training for the study period. The factor was also measured on a four scale rating of extent to which it impacts on the development of TC in firms thus; 4-Highly, 3-Moderately, 2-Slightly, and 1-not at all.

vi. Funds for R&D (x_6)

Although R&D is valued as an integral function of technological capability and technological innovation, it is usually very expensive and some firms could shy away from it due to lack of funds. The respondents were asked to state the amount spent on R&D for the study period. The factor was measured on a four scale rating of extent to which it impacts on the development of TC in firms thus; 4-Highly, 3-Moderately, 2-Slightly, and 1-not at all.

vii Working Experience (x_7)

The experience of the owner of the firm would be measured on the basis of previous employment as well as the number of years in the present employment. This criterion is one of the ways used in determining the technological capability of the entrepreneurs. The factor was measured on a four scale rating of extent to which it impacts on the development of TC in firms thus; 4-Highly, 3-Moderately, 2-Slightly, and 1-not at all.

viii. Linkages (x_8)

Informational links established by firms could increase value added The respondents were asked to state the extent in which the factor has influenced the technological capability of their firms using a four scale rating of 4-Highly, 3-Moderately, 2-Slightly, and 1-not at all.

ix. Trade orientation (i.e. import-oriented regimes or export-oriented) (x_9)

Trade orientation of an enterprise can impact on the development of technological capability. Import-oriented enterprises, in the process of use of imported technologies could develop production capability. In fact, such mastery are usually displayed in cases where the firm has a sound policy on reverse engineering. This was how China attained its present industrial development. This parameter was measured on a four scale rating of extent to which it impacts on the development of TC in firms thus; 4-Highly, 3-Moderately, 2-Slightly, and 1-not at all.

x. Size of firm (x_{10})

The extents to which firm-level differences in technological effort and mastery occur vary by industry as well as by size of firm and market. This is because the size of a firm will determine the technological strategy, the level of risk and the eventual result of technological efforts and invariably the technological capability of firms. Thus, the parameter was measured on a four scale rating of extent to which it impacts on the development of TC in firms thus; 4-Highly, 3-Moderately, 2-Slightly, and 1-not at all.

xi. Availability of micro-level learning support mechanisms (x_{11})

Technological knowledge is not shared equally among firms, nor is it easily imitated by or transferred across firms. Transfer necessarily requires learning because technologies are tacit, and their underlying principles are not always clearly understood. Therefore, simply to gain mastery of a new technology requires skills, effort, and investment by the receiving firm, and the extent of mastery achieved is uncertain and necessarily varies by firm according to these inputs. The factor was measured on a four scale rating of extent to which it impacts on the development of TC in firms thus; 4-Highly, 3-Moderately, 2-Slightly, and 1-not at all.

B External factors:

i. Competition with international market (y_1)

The respondents would be asked to state the extent in which competition with local and international market has influenced the technological capability of their firms using a four item scale rating of 4-Highly, 3-Moderately, 2-Slightly, and 1-not at all.

ii. Technological change (y_2)

Technological change impacts on technological capability building in the sense that as new technologies and processes emerge, competence in use and adaptations are developed to match the new technologies. In ICTs the rate of technological obsolesces is higher due to the dynamic nature of the industry. The factor was measured on a four scale rating of extent to which it impacts on the development of TC in firms thus; 4-Highly, 3-Moderately, 2-Slightly, and 1-not at all.

iii Government support and policy toward education, particularly education in science and engineering (y_3)

Technological capability development is being influenced by government support in the provision of adequate infrastructure and conducive business environment for firms. Nationwide policies in the form of macroeconomic policies, financial system development, incentive structures, infrastructure, and national education attainment have important impacts on the capabilities and efficiency of firms. The factor was measured on a four scale rating of extent to which it impacts on the development of TC in firms thus; 4-Highly, 3-Moderately, 2-Slightly, and 1-not at all.

iv. Skills from the labour market (y_4)

Access to skills and expertise from the labour market could impact on technological capabilities of firms. In a sense, good and skilled labour are scarce and when they are found, firms may be required to pay a premium. Small firms may not be able to afford this. Thus, capabilities which facilitate adoption and efficient use of technologies often cannot be found or are not readily available on the market. Markets for knowledge and other such inputs are also characterized by imperfections. As a consequence, the process of technology development itself inevitably creates technology gaps. This parameter was measured on a four scale rating of extent to which it impacts on the development of TC in firms thus; 4-Highly, 3-Moderately, 2-Slightly, and 1-not at all.

v. Technical information and support (y_5)

Aside from skills available in the labour market. The firm may have need for specific technical information and support relevant to a process or product development which are external and not within its jurisdiction. The factor was measured on a four scale rating of extent to which it impacts on the development of TC in firms thus; 4-Highly, 3-Moderately, 2-Slightly, and 1-not at all.

vi. Access to technology infrastructure of laboratories, testing facilities, standards institutions, and so on (y_6)

This parameter was measured on a four scale rating of extent to which it impacts on the development of TC in firms thus; 4-Highly, 3-Moderately, 2-Slightly, and 1-not at all.

vii. Access to appropriate technology (y_7)

The factors was measured on a four scale rating of extent to which it impacts on the development of TC in firms thus; 4-Highly, 3-Moderately, 2-Slightly, and 1-not at all.

viii. Licensing (y_8)

Technology transfer through technical assistance contracts or licensing arrangements could enhance technological capability development. Direct foreign investment could increase the ability of firms to "learn-by-copying" and the ability to "benchmark" their operations against internationally competitive firms in the same business (World Bank, 1996). The respondents would be asked to state the extent in which the factor has influenced the technological capability of their firms using a four item scale of 4-Highly, 3-Moderately, 2-Slightly, and 1-not at all.

10.0 Measurement of the Impact of Technological Capability on Firm's Performance

Impacts of technological capability development on firm's performance range from effects on sales and market share to changes in productivity and efficiency. Important impacts at industry and national levels are changes in international competitiveness and in total factor productivity, knowledge spill over of firm-level innovations, and an increase in the amount of knowledge flowing through networks. The impact of technological capability accumulation can also be measured by the percentage of sales derived from new/improved products and number of patents.

To evaluate the impact of technological capability accumulation on firm's performance based on annual profit, the following model was considered as relevant: Performance (P) of ICT firms in terms of profitability in the last accounting year is considered as an objective function with several independent variables X_i. Mathematically, this is expressed as:

$$P = \sum f(TC_{i+j+k}) = \sum[f(IC_i) + f(PC_j) + f(NLC_k)] \quad \text{........ equation 2}$$

Where:

TC = Technological Capability; IC = Investment Capability; PC = Production Capability; NLC = Networking and Linkage Capability;

i = (1, 2, 3…, 6) investment capabilities in the ICT firms

j = (1, 2, 3…, 12) production capabilities and

k = (1, 2, 3 …, 3) networking capabilities in the ICT firms

P = Performance (Measured in terms of annual profit in naira)

IC_1 = feasibility studies (based on number of successful feasibility studies and rating of ability/skill of firm to perform the function in-house)

IC_2 = search for technology (based on rating of ability/skill of firm to perform the function in-house)

IC_3 = assessment of technology (based on rating of ability/skill of firm to perform the function in-house)

IC_4 = equipment/machinery/facility procurement (based on rating of ability/skill of firm to perform the function in-house)

IC_5 = recruitment of skilled personnel (based on number of skilled personnel recruited and rating of ability/skill of firm to perform the function in-house)

IC_6 = involvement in detailed engineering (based on rating of ability/skill of firm to perform the function in-house)

TC_1 = quality control (based on actual number of skilled personnel and rating of ability/skill of the enterprise to carry out the function in-house)

TC_2 = debugging (based on actual number of skilled personnel and rating of ability/skill of the enterprise to carry out the function in-house)

TC_3 = preventive maintenance (based on actual number of skilled personnel and rating of ability/skill of the enterprise to carry out the function in-house)

TC_4 = Plant layout (based on actual number of skilled personnel and rating of ability/skill of the enterprise to carry out the function in-house)

TC_5 = inventory control (based on actual number of skilled personnel and rating of ability/skill of the enterprise to carry out the function in-house)

TC_6 = improvement in processes (based on rating of success/functionality of processes improved, actual number of skilled personnel and rating of ability/skill of firm to perform the function in-house)

TC_7 = copying imports (based on rating of success/functionality of imports copied, actual number of skilled personnel and rating of ability/skill of firm to perform the function in-house)

TC_8 = improving existing products (based on rating of success/functionality of products improved, actual number of skilled personnel and rating of ability/skill of firm to perform the function in-house)

TC_9 = introducing new products (based on rating of success/functionality of introduced products, actual number of skilled personnel and rating of ability/skill of firm to perform the function in-house)

TC_{10} = licensing new product technology (based on number of skilled personnel and rating of ability/skill of the firms to carry out the function in-house)

TC_{11} = experimental development (based on amount spent in R&D, actual number of skilled personnel and rating of the ability/skill of the firms to carry out the function in-house)

TC_{12} = Patents (based on the number of patents granted)

NLC_1 = government laboratories (based on the number of existing linkages and rating of the intensity of firm collaborative effort)

NLC_2 = universities or polytechnics (based on the number of existing linkages and rating of the intensity of firm collaborative effort)

NLC_3 = ICT regulatory body (based on the number of existing linkages and rating of the intensity of firm collaborative effort)

NLC_4 = competitors (based on the number of existing linkages and rating of the intensity of firm collaborative effort)

NLC_5 = suppliers (based on the number of existing linkages and rating of the intensity of firm collaborative effort)

NLC_6 = financial resources (based on the number of existing linkages and rating of the intensity of firm collaborative effort)

11.0 Development of computer software for technological capability evaluation and review

To develop computer software for technological capability evaluation and review, the study used the flowchart in figure 5 to write the algorithm. The software algorithm was developed from the time-series information obtained on TCs and performance indicators. The Visual Basic Programming Language was used to develop the software to evaluate and review TCs in the industry. The data from the study are being used to validate the software.

The pseudo code of the algorithm in Figure 5 is as follows:

START

OBTAIN INVESTMENT CAPABILITY

$IC_{1previous}$ = obtain number of successful feasibility studies and rating of ability/skill of firm to perform feasibility study in-house in previous year

$IC_{1current}$ = obtain number of successful feasibility studies and rating of ability/skill of firm to perform feasibility study in-house in current year

$IC_{2previous}$ = obtain rating of ability/skill of firm to perform search for technology in previous year.

$IC_{2current}$ = obtain rating of ability/skill of firm to perform search for technology in current year

$IC_{3previous}$ = obtain rating of ability/skill of firm to perform assessment of technology in-house in previous year

$IC_{3current}$ = obtain rating of ability/skill of firm to perform assessment of technology in-house in current year

$IC_{4previous}$ = obtain rating of ability/skill of firm to perform equipment/machinery/facility procurement in-house in previous year

$IC_{4current}$ = obtain rating of ability/skill of firm to perform equipment/machinery/facility procurement in-house in current year

$IC_{5previous}$ = obtain number of skilled personnel recruited and rating of ability/skill of firm to perform recruitment of skilled personnel in-house in previous year

$IC_{5current}$ = obtain number of skilled personnel recruited and rating of ability/skill of firm to perform recruitment of skilled personnel in-house in current year

$IC_{6previous}$ = obtain rating of ability/skill of firm to participate in detailed engineering in previous year

$IC_{6current}$ = obtain rating of ability/skill of firm to participate in detailed engineering in current year

OBTAIN PRODUCTION CAPABILITY

$TC_{1previous}$ = obtain actual number of skilled personnel and rating of ability/skill of the enterprise to carry out quality control in-house in previous year

$TC_{1current}$ = obtain actual number of skilled personnel and rating of ability/skill of the enterprise to carry out quality control in-house in current year

$TC_{2previous}$ = obtain actual number of skilled personnel and rating of ability/skill of the enterprise to carry out debugging in-house in previous year

$TC_{2current}$ = obtain actual number of skilled personnel and rating of ability/skill of the enterprise to carry out debugging in-house in current year

$TC_{3previous}$ = obtain actual number of skilled personnel and rating of ability/skill of the enterprise to carry out preventive maintenance in-house in previous year

$TC_{3current}$ = obtain actual number of skilled personnel and rating of ability/skill of the enterprise to carry out preventive maintenance in-house in current year

$TC_{4previous}$ = obtain actual number of skilled personnel and rating of ability/skill of the enterprise to carry out Plant layout in-house in previous year

$TC_{4current}$ = obtain actual number of skilled personnel and rating of ability/skill of the enterprise to carry out Plant layout in-house in current year

$TC_{5previous}$ = obtain actual number of skilled personnel and rating of ability/skill of the enterprise to carry out inventory control in-house in previous year

$TC_{5current}$ = obtain actual number of skilled personnel and rating of ability/skill of the enterprise to carry out inventory control in-house in current year

$TC_{6previous}$ = obtain rating of success/functionality of processes improved, actual number of skilled personnel and rating of ability/skill of firm to perform improvement in processes in-house in previous year

$TC_{6current}$ = obtain rating of success/functionality of processes improved, actual number of skilled personnel and rating of ability/skill of firm to perform improvement in processes in-house in current year

$TC_{7previous}$ = obtain rating of success/functionality of imports copied, actual number of skilled personnel and rating of ability/skill of firm to copy imports in-house in previous year

$TC_{7current}$ = obtain rating of success/functionality of imports copied, actual number of skilled personnel and rating of ability/skill of firm to copy imports in-house in current year

$TC_{8previous}$ = obtain rating of success/functionality of products improved, actual number of skilled personnel and rating of ability/skill of firm to improve existing products in-house in previous year

$TC_{8current}$ = obtain rating of success/functionality of products improved, actual number of skilled personnel and rating of ability/skill of firm to improve existing products in-house in current year

$TC_{9previous}$ = obtain rating of success/functionality of introduced products, actual number of skilled personnel and rating of ability/skill of firm to introduce new products in-house in previous year

$TC_{9current}$ = obtain rating of success/functionality of introduced products, actual number of skilled personnel and rating of ability/skill of firm to introduce new products in-house in current year

$TC_{10previous}$ = obtain number of skilled personnel and rating of ability/skill of the firms to carry out licensing of new product technology in-house in previous year

$TC_{10current}$ = obtain number of skilled personnel and rating of ability/skill of the firms to carry out licensing of new product technology in-house in current year

$TC_{11previous}$ = obtain amount spent in R&D, actual number of skilled personnel and rating of the ability/skill of the firms to carry out experimental development in-house in previous year

$TC_{11current}$ = obtain amount spent in R&D, actual number of skilled personnel and rating of the ability/skill of the firms to carry out experimental development in-house in current year

$TC_{12previous}$ = obtain number of patents granted in previous year

$TC_{12current}$ = obtain number of patents granted in current year

OBTAIN LINKAGE CAPABILITY

$NLC_{1previous}$ = obtain number of existing linkages and rating of the intensity of firm collaborative effort with government laboratories in previous year

$NLC_{1current}$ = obtain number of existing linkages and rating of the intensity of firm collaborative effort with government laboratories in current year

$NLC_{2previous}$ = obtain number of existing linkages and rating of the intensity of firm collaborative effort with universities or polytechnics in previous year

$NLC_{2current}$ = obtain number of existing linkages and rating of the intensity of firm collaborative effort with universities or polytechnics in current year

$NLC_{3previous}$ = obtain number of existing linkages and rating of the intensity of firm collaborative effort with ICT regulatory body in previous year

$NLC_{3current}$ = obtain number of existing linkages and rating of the intensity of firm collaborative effort with ICT regulatory body in current year

$NLC_{4previous}$ = obtain number of existing linkages and rating of the intensity of firm collaborative effort with competitors in previous year

$NLC_{4current}$ = obtain number of existing linkages and rating of the intensity of firm collaborative effort with competitors in current year

$NLC_{5previous}$ = obtain number of existing linkages and rating of the intensity of firm collaborative effort with suppliers in previous year

$NLC_{5current}$ = obtain number of existing linkages and rating of the intensity of firm collaborative effort with suppliers in current year

$NLC_{6previous}$ = obtain number of existing linkages and rating of the intensity of firm collaborative effort with financial resources in previous year

$NLC_{6current}$ = obtain number of existing linkages and rating of the intensity of firm collaborative effort with financial resources in current year

OBTAIN ANNUAL PROFIT/TURNOVER (P)

(a) $P_{previous}$ = Get the annual turnover/profit in previous year

(b) $P_{current}$ = Get the annual turnover/profit in current year

PERFORM DECISION ANALYSIS

if $IC_{1current} > IC_{1previous}$ and/or $IC_{2current} > IC_{2previous}$ and/or $IC_{3current} > IC_{3previous}$ and/or $IC_{4current} > IC_{4previous}$ and/or $IC_{5current} > IC_{5previous}$ and/or $IC_{6current} > IC_{6previous}$ and/or $TC_{1current} > TC_{1previous}$ and/or $TC_{2current} > TC_{2previous}$ and/or $TC_{3current} > TC_{3previous}$ and/or $TC_{4current} > TC_{4previous}$ and/or $TC_{5current} > TC_{5previous}$ and/or $TC_{6current} > TC_{6previous}$ and/or $TC_{7current} > TC_{7previous}$ and/or $TC_{8current} > TC_{8previous}$ and/or $TC_{9current} > TC_{9previous}$ and/or $TC_{10current} > TC_{10previous}$ and/or $TC_{11current} > TC_{11previous}$ and/or $TC_{12current} > TC_{12previous}$ and/or $NLC_{1current} > NLC_{1previous}$ and/or $NLC_{2current} > NLC_{2previous}$ and/or $NLC_{3current} > NLC_{3previous}$ and/or $NLC_{4current} > NLC_{4previous}$ and/or $NLC_{5current} > NLC_{5previous}$ and/or $NLC_{6current} > NLC_{6previous}$ and/or $P_{current} > P_{previous}$

THEN report result and summarize ‘technological capability is SATISFACTORY’

ELSE

REPORT result and summarize ‘There is need to (i) improve on technological capability of firm (ii) analyze and optimize factors that can improve on technological capability accumulation and; (iii) improve on government policy to support firm.

GO TO START

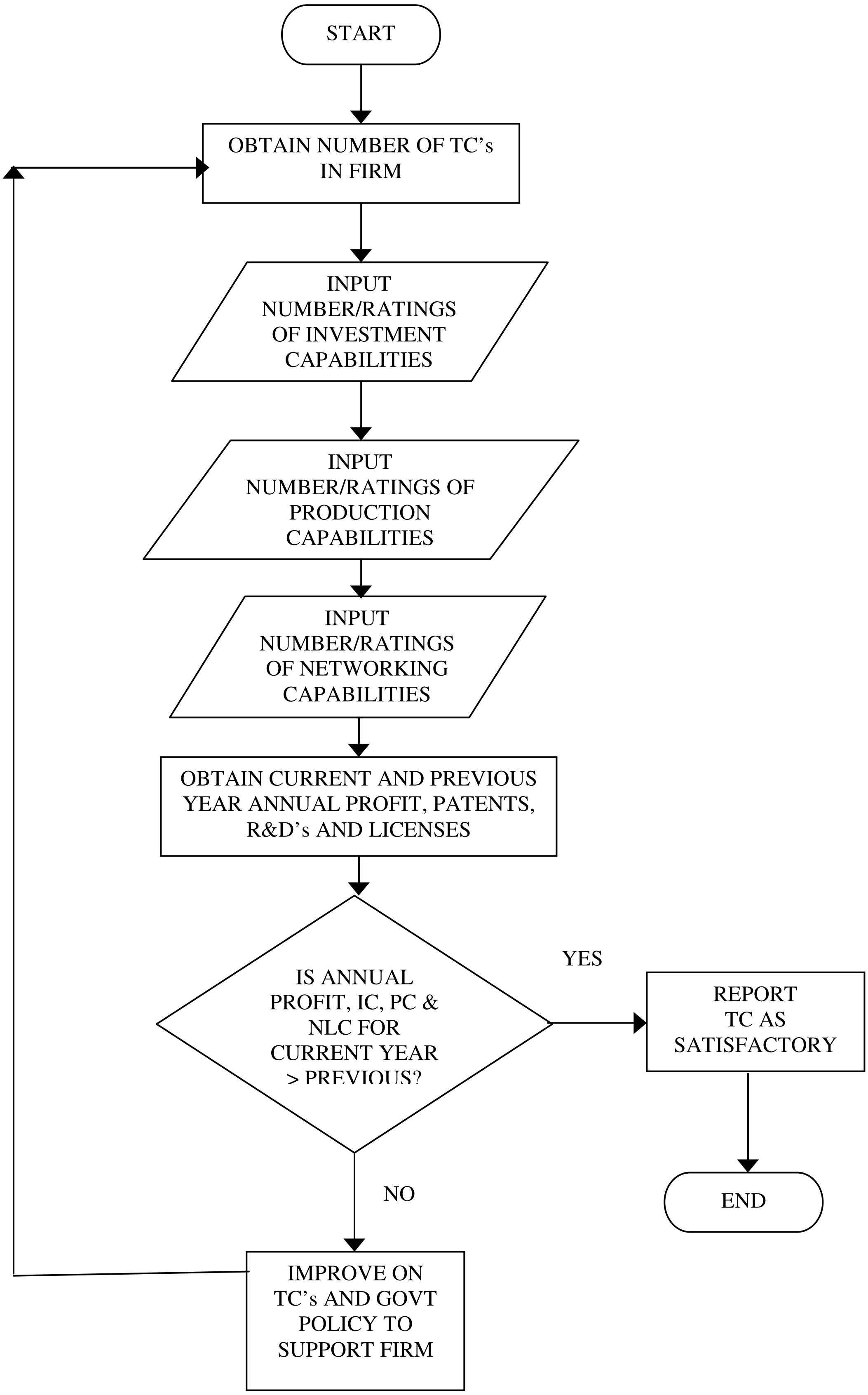

Figure 5: Flowchart for Technological Capability Evaluation and Review in Firms

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